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BIOLOGIA

Vol. 2 JUNE 1956 No. 1

Growth and nutritional requirements of *Rosellinia necatrix* (Hart.) Berlese with special reference to the production of perithecia

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Rosellinia necatrix (Hart.) Berl. is a serious pathogen in orchards and occurs on a wide variety of host plants. It affects 170 species spread over 63 genera and thirty families besides certain algae. It is confined primarily to temperate climates. The fungus has well marked vegetative phase but perithecia are produced rarely. Apart from a study of the pathogenicity of this fungus, its temperature, water, pH and nutritional relations were studied in culture to determine the conditions required to secure the production of perithecia.

Seven isolates were used from several suscepts and localities, all but one from California. The results of these studies have been set out in the following pages.

1. EFFECT OF DIFFERENT MEDIA ON GROWTH

Viala (1891) carried out experiments with manure, vegetable mould, heath soil mixed with wood waster or sawdust and rich alluvial soil irrigated with liquid manure (*purin*). The growth on all these substrates was very 'beautiful'. 0.1 to 1.0 percent of ammonium nitrate, ammonia, sodium nitrare, ammonium phosphate, and potassium nitrate added to soil, activated the development of flocculent mycelium and rhizoidal cords.

Perotti (1940) has reported that mycelium of *R. necatrix* develops abundantly on a decoction of mushrooms and especially on one of carrots. At first white, the mycelium slowly becomes gray, forming sheets and floccose cords.

In the present investigations eight media, namely potato-dextrose-agar, oatmeal-agar, prune-agar, Czapek's-agar ; Czapek's with glucose (25 gms/litre), malt extract 2.5%, peptone 1% and yeast extract 0.5% were tried. Besides these, malt extract, peptone and yeast extract were added to the basic complete nutrient solution of Hoagland & Arnon (1938) which contained 2.5% of dextrose. Henceforth Hoagland's solution with the addition of glucose will be referred to as 'nutrient solution' or 'nutrient medium' if agar is added. Hoagland & Arnon's formula is given below :-

Solution (i)

M/1 per litre calcium nitrate	= 5 c. c.
M/1 per litre potassium nitrate	= 5 c. c.
M/1 per litre magnesium sulphate	= 2 c. c.
M/1 per litre potassium dihydrogen phosphate	= 1 c. c.

Total made up to 1 litre

Solution (ii)

Boron	0.5	p. p. m.
Cu	0.02	,,
Zn	0.1	,,
Mn	0.5	,,
Mo	0.01	,,

Solution (iii)

Fe is taken as 1 c. c. of 1% Fe tartarate.

Six c. c. of (i), one c. c. of (ii) and one c. c. of (iii) are made up to one litre.

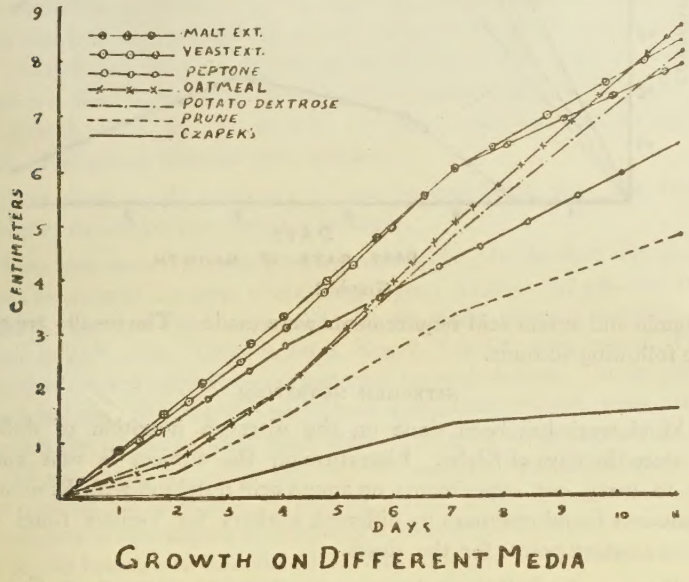
Nitrate medium was selected because nitrate offers most satisfactory source of nitrogen for perithecia and spore formation as well as normal nitrogen nutrition in many fungi. (Westergaard & Mitchell, 1947 and Brain *et al*, 1947).

The pH of the media was determined by the colorimetric method. The pH was 5.8-6.0 in all cases except prune agar medium where it was only 3.8. Twenty five c. c. of the agar medium was poured in petri dishes and the inoculum placed near one edge of the dish. The amount of inoculum used was kept as uniform as feasible, by using standardized agar discs. The disc 0.5 cm. in diameter, was lifted with a sterile platinum spatula and transferred to the medium under test. The cultures were kept at room temperature (25 to 28° C). Five isolates of the fungus were tried for each medium and each test had 4 replications. With Czapek's medium three replications were tried. A cutting of *R. linderae* Pk., which is a slow growing fungus, was used as a check.

RESULTS : Growth on *potato dextrose agar* was very fluffy, aerial and cottony, and with a wavy growing margin. Vigorous mycelium touched the upper cover of the petri dish and mycelial strands were

formed. On *oatmeal agar* the growth was consistently most vigorous. The mycelial mat was moderately aerial and uniform in all directions, so that the margin of the colony was entire. The growth on *prune agar* was thin, silky, sparse and appressed. There were very few aerial hyphae. The growth on *Czapek's agar* was definitely poor. It was very sparse, neither cottony nor aerial, sometimes as button of cheesy growth. This indicated that the fungus needed something more for its growth than mere inorganic salts and carbohydrate.

Differences in total growth noted in five isolates on oatmeal, potato dextrose, yeast or malt extract agars are shown in Graph 1.

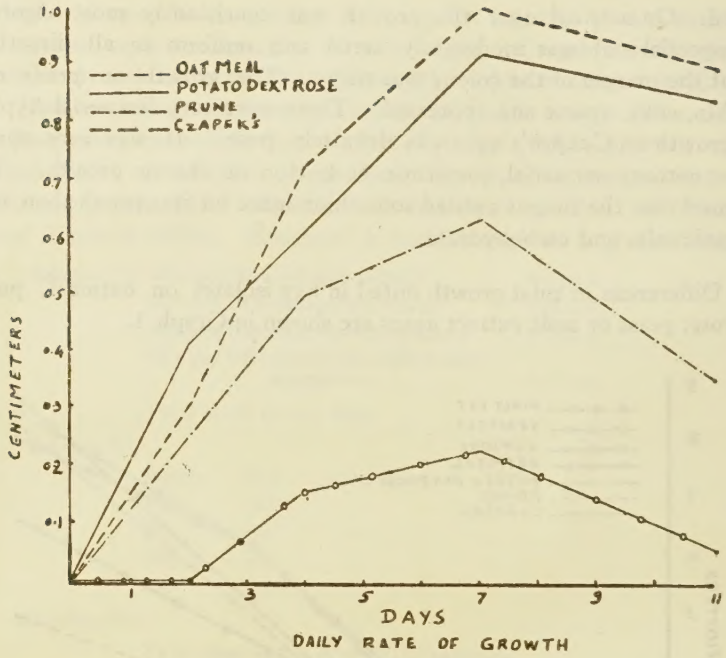


GROWTH ON DIFFERENT MEDIA

Graph 1.

The daily growth rate was highest on oatmeal agar and next on potato dextrose agar. The rate of growth (Graphs 1 & 2) recorded an increase for 7 days, but slowed down afterwards. The total growth made by different isolates is given in Tables 1 & 2 and Graph 1. Relative growth on yeast extract, malt extract and peptone, are given in Tables 3 & 4. Growth on inorganic media plus glucose is shown in Table 5.

In order to explore the possibility of using suitable vitamins and amino acids as aids to the utilization of other carbohydrates, experiments



Graph 2.

on vitamin and amino acid requirements were made. The results are given in the following account.

NITROGEN NUTRITION

Much work has been done on the nitrogen nutrition of different fungi since the days of Klebs. Literature on the subject is vast and in order to carry out experiments on amino acid nutrition with *R. necatrix*, the amounts found optimum by different workers for various fungi were taken as starting points for the doses.

The growth of all the isolates was more meagre or scant on Czapek's than on Hoagland's plus glucose.

2. CARBOHYDRATE NUTRITION

Most fungi thrive on carbohydrates although some of them can utilise fats, oils and proteins as sources of carbon. Glucose is most readily used by the fungi in general. The problem has been attacked lately by Moore (1937), Steinberg (1942), Perlman (1948) and Cantino (1948), and the findings of these authors have formed the basis for selecting the initial quantities to be used in the various experiments.

The fourteen carbohydrates, which were tried at the concentration

of 25 gms. per litre each, may be listed as follows : *Monosaccharides*—xylose, l-arabinose, dextrose-d-levulose, d-galactose, and d-mannose ; *Disaccharides*—maltose, lactose, and sucrose ; *Trisaccharides*—raffinose ; *polysaccharides*—glycogen, starch, dextrin and gum acacia.

These were added to the basic nutrient medium along with pyridoxine because the latter promoted growth.

Two tests were conducted using two isolates and three petri dishes under each. The petri dishes were stored, under glass cover, in the room at 25-28°C.

In the first test there was no growth on any one of the carbohydrates tried except on soluble starch. In the second test (Table 6) there was only a very negligible growth in dextrose, maltose, lactose and sucrose. Some growth occurred on glycogen and starch, being better on the latter. Isolate No. 8 did not grow on any of these media but No. 2 was more responsive. Maltose was next to starch in the extent of growth supported. On the whole growth was much too weak as compared with the controls (quince sawdust, and quince sawdust plus glucose).

From these weak responses it can be concluded that the fungus likes higher carhohydrates with 1-4 linkages.

Two tests were conducted with amino acids. In the first test glycine 0.2 gm., asparagine 2.0 gms. d-alanine 0.2 gm., cystine 0.2 gm. and tryptophane 0.1 gm. per litre, were used with the basic nutrient medium and dextrose in 2.0% agar. Three isolates, Nos. 2, 5 and 8, were tested. Three replications of each chemical were included for each isolate. In the second test two isolates, Nos. 2 and 8 with three replications of each, were tested. The quantities of amino acids used were 0.14 gm. of nitrogen per litre (or 0.14μ gm. per c. c.). The pH of the medium was adjusted to 5.8 before pouring out in plates. The petri dishes were cleaned with ivory soap, washed in running water over night, rinsed in 3 changes of distilled water for 10 hours, and then rinsed in two changes of redistilled water. Solutions were made in redistilled water.

There was no evidence of promotion of growth by any one of the amino acids tried and only a negligible, very weak, button type of growth was observed around the inoculum on d-alanine, leucine, isoleucine, methionine and arginine. Apparently, substances like asparagine were not utilised while glycine, histidine and tryptophane were toxic in a medium containing pyridoxine.

3. VITAMIN REQUIREMENTS

It is now an established fact that the various fungi require vitamins

and that all species do not have similar requirements. Doses of vitamins used by earlier workers, namely Leonian & Lilly (1938), Beadle & Tatum (1945) Burkholder & Sinnott (1945) and Barnett & Lilly (1949), were selected for experiments with *R. necatrix*. Biotin 6.4 μ gms.; thiamine 200 μ gms.; pyridoxine 500 μ gms. ; riboflavin 200 μ gms. ; pantothenic acid 200 μ gms. ; nicotinamid 200 μ gms. ; and inositol 6 μ gms. per litre, were the doses used.

Since it had been observed that the growth was very poor on Czapek's agar medium or nutrient solution or the nutrient glucose medium, various vitamins were, therefore, incorporated in these media to improve growth. In all six trials were made. In the first trial, thiamine and pyridoxine were tried on isolates Nos. 2, 3, 5, 7 and 8. The vitamins were added to the nutrient agar which was then autoclaved and dispensed in sterile petri dishes. The pH of the medium was adjusted to 5.8 before sterilization. In the second and third tests thiamine, pyridoxine, and biotin were used separately and all together. Commercial agar was washed with distilled water and then dried at low heat. The petri dishes were also washed with distilled water.

In the fourth, fifth and sixth trials the conditions of the experiment were made more rigid. The petri dishes were washed first with pure soap, rinsed overnight with running water, immersed for 12 hours in distilled water, finally rinsed in water redistilled in glass, and then sterilised. All apparatus used in the experiment was treated in the same manner. The vitamin solutions were sterilized by filtering through Smith's filter (Rawlins, 1933) and added to flasks of sterilised nutrient agar by means of sterile pipettes. The medium was dispensed in the petri dishes through graduated dispenser tube attached to the flasks. The results are given in the Tables 7 and 8.

The first two tests showed no more growth than the check (nutrient agar only). In the third test there was better growth with biotin, thiamine and pyridoxine. One of the four isolates (Number 8) proved to be very sensitive to the absence of biotin and did not grow in cultures where it was absent. Other isolates however showed a slight growth (Fig. 1 & Table 7). Growth on various combinations of the above three vitamins was slightly better wherein biotin was a component. In pyridoxine and thiamine combination as compared to individual vitamins, the difference was not appreciable in all cases. In the fourth test only biotin was used, with potato-dextrose as a check (to estimate whether the growth was of the same vigor and extent as on the complex media). Isolates Nos. 2,5 and 8 grew in biotin but the growth was not as vigorous and as fluffy as in potato-dextrose

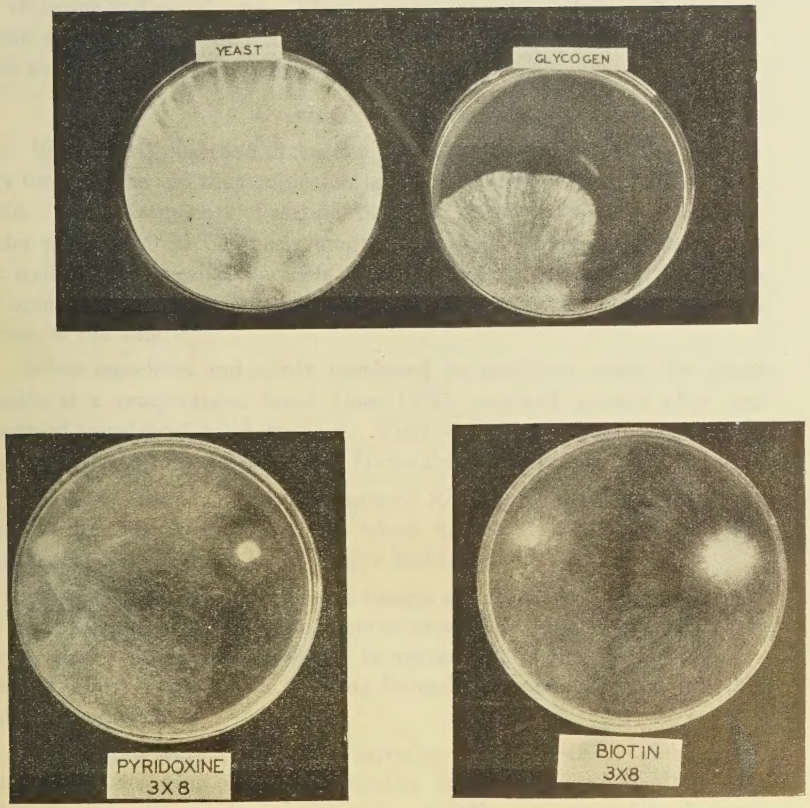


FIG. 1

Top : Petri dishes showing growth of **Rosellinia necatrix** on Hoagland's basic medium with the additions indicated. *Bottom left :* A petri dish with a typical culture (No. 3) on the left and culture No. 8 on the right. *Bottom right :* Same cultures with biotin.

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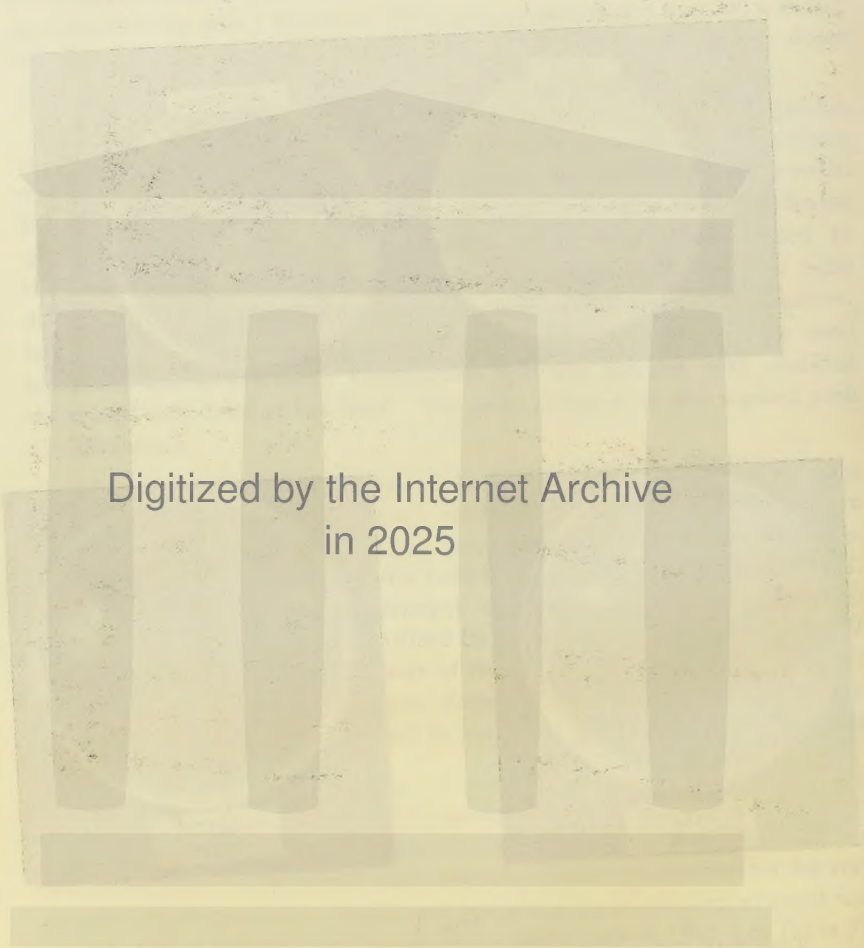

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agar (Table 8). In the fifth and sixth trials all the vitamins listed above with the exception of biotin, were used. No growth was obtained with any of these including thiamine and pyridoxine and their combinations. This showed that the deficiency for biotin was total and probably partial for thiamine and pyridoxine. There was no apparent deficiency for pantothenic acid, nicotinamide, riboflavin, or inositol. The last result is in contrast to Hawker's (1936) findings with *R. necatrix*.

4. WATER RELATIONS

Viala (1891) observed that when dry material was kept in the laboratory for one year and then subjected to moist conditions, the fungus grew again. When fragments of rotting but not decomposed vine were put under water at 20-30°C for one month the tissues were pulverised, but the walls of the mycelial filaments remained intact. This test proved in his opinion that the mycelium of the fungus was more resistant than the tissues of the vine.

White mycelium and cords immersed in sterilized water for three months at a temperature lower than 15°C, renewed growth after one month of transfer to solid medium. Viala kept his cultures on vine and cherry roots alive for 9 years under favourable conditions.

Two to three cms. long fragments of *Rhizomorpha subterranea*, kept in flasks for two years, produced white flocculent mycelium from the central medulla after one month and a half (Viala *op. cit.*).

Pierce (1892) believed that the fungus will retain life without water for many months even when the roots or canes have been removed from the ground. This was observed in material brought from Europe. Mercuri (1928) found that *R. necatrix* formed sclerotial crusts under dry and hot conditions.

Three tests were made by the writer to study the effect of moisture gradients or desiccation on the viability of the fungus. Cultures on oatgrains were allowed to dry up for one month, and then tested every week for 9 weeks for powers of revival of the fungus growth after drying. The results are given below :

1–2	weeks	...	...	growth	observed	after	4	days
3	,,	...	...	,,	,,	,,	5	,,
4	,,	...	...	,,	,,	,,	6	,,
6–9	,,	...	...	,,	,,	,,	10	,,

In the second test, isolates 1,2,4 and 5 were grown on sterilized twigs for 3 weeks till all the twigs were covered with the fungus. Moisture content of one lot of the check was determined each time. One flask

containing 6 pieces of fungus-covered twigs, of each isolate, was taken out periodically and water was added to it to revive the fungus. Moisture content was determined at each time of sampling. The results are tabulated in Table 9. Isolates No. 2,4 and 5 were used in duplicate, consisting of 6 pieces of quince wood.

All cultures survived for 9 months when water content was reduced to 5.5-9.6% and a few remained viable for at least fifteen months when moisture content had declined to 4%. The cultures were stored at 25-28°C.

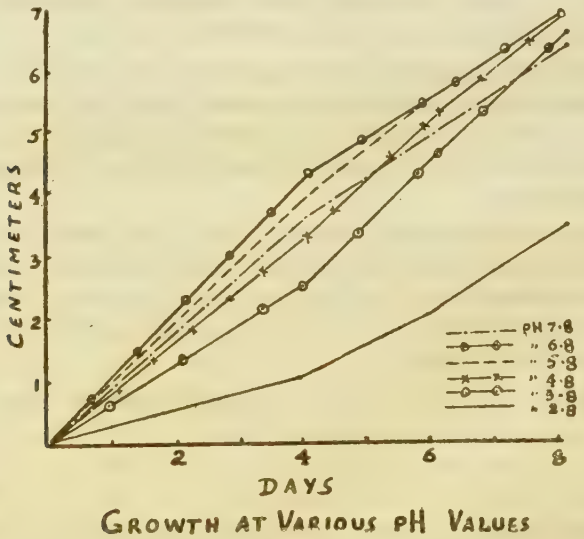
The third test which continued for 9 months, showed that all the fungus isolates were viable up to the end of that period.

5. EFFECT OF H-ION CONCENTRATION

Waterston (1941) working on *R. pepo* did not find any relation between soil pH, nitrogen, organic matter and available potassium and phosphorus, and the incidence of disease. Suba Rao (1941) found that the root rots due to *R. arcuata* and *R. bunodes* thrived in neutral to alkaline conditions and tolerated moderately acid ones.

As regards the pH relations of *R. necatrix*, three experiments were conducted in potato dextrose, two in agar and one in liquid culture media.

The first test covered the range from 3.8 to 6.8 at intervals of one pH unit, and the other extended from pH 2.8 to 7.8.



Graph 3.

Five isolates of the fungus Nos. 2, 3, 5, 7 and 8 were tried at each

H-ion concentration. Two replications with each isolate were made. The results have been summarized in Table 10.

Growth on the solid medium was good at a pH from 3.8 to 6.8, somewhat less at 7.8 and poor at 2.8. The optimum initial pH was at 5.8 or slightly higher. In liquid culture the best pH was found to be 5.8 and next in order were 6.8 and 4.8. Mycelium formed a dense felty mass on the surface of the liquid. There was no mycelial growth at pH 2.8 or 3.8 in the liquid culture. At pH 7.8 the mycelium was poor. The pH of the liquid tested at the end of 35 days was about the same for all cultures (8. 2 to 8.4) except for those which started at 2.8 and 3.8. These ended at 3.0 and 3.6, respectively, (cf. Table 11).

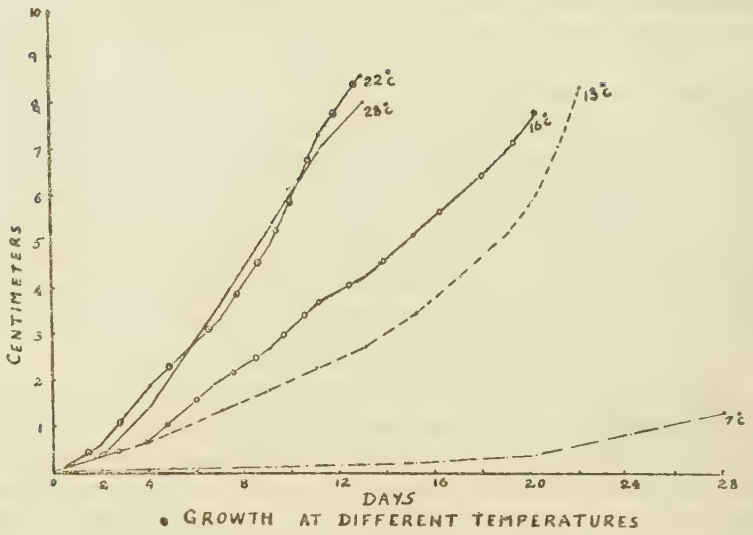
The mycelium on petri dishes containing potato-dextrose agar adjusted to various pH values was crushed on slides after 10 days of incubation and indicator drops were added to it. The mycelium invariably showed a pH range from 6.8 to 7.2. The surface agar medium was tested in the same way. This also showed higher values than the original pH of the media. The medium deeper down in the petri dishes had approximately the same pH as adjusted at the beginning of the experiments.

6. EFFECT OF TEMPERATURE

Viala (1891) observed that when the temperature was lowered to 5-7° C the external mycelium disappeared without producing reproductive organs. The growth was resumed at 15-20° C. At 38° C the flocculent mycelium was killed on the outside of the host tissue and when the material was transferred to normal temperature, it revived. The mycelium was killed if kept at 65° C for 2-3 hours. The mycelium was more resistant than the tissues it invaded. It developed actively at 12-25° C. The mycelium in the host tissues survived at temperatures ranging from—4° C to 38° C. Mercuri (1928) reported the optimum temperature to be 16-18° C in cultures. Rivera (1946) kept cultures of *R. necatrix* on sterile wet straw for 17 days at 8°, 16°, 22°, 25° and 43° C. At 22° and 25°C the bottles were filled with mycelium after 7 days. At 8° C no growth occurred but the fungus was viable, whereas at 43° C the fungus was killed.

In the present investigations cultures of three isolates of the fungus were grown on oatmeal agar and stored at 12 different temperatures, viz., 0°, 4°, 7°, 10°, 13°, 16°, 19°, 22°, 25°, 31°, 34°, and 40° C. Observations were made at two-day intervals and radial growth measured.

All the three isolates showed the same trend. The results are given in Table 12. Very vigorous growth occurred at temperatures of 22-28°C. Maximum growth was at 22° C to 25°C (Graph 4). At 0°C there was no



Graph 4.

growth of the fungus even after 39 days but when the inoculum was transferred to room temperature (25-28°C) the fungus started to grow after fifteen days of incubation.

The cultures stored at 4°C did not grow but when transferred to 25-28°C they resumed growth after 9 days. At 7°C the first visible growth appeared after 15 days. At 10° C growth started in four days. At 31°C the fungus showed practically no growth, but when transferred to fresh oatmeal agar at 25° C it started to grow again on the 9th day. The fungus was killed at 34° C and 40° C within 9 days of exposure.

The above results show that the lethal temperature limit was much lower than given by Rivera (1946) and Viala (1891). The optimum (22°C) is much closer to Rivera's 22-25°C, but the range (7-25°C) is much wider than is indicated by Rivera.

7. ATTEMPTS TO PRODUCE THE REPRODUCTIVE ORGANS

Viala (1891) stated that he was never able to obtain conidiophores or perithecia on the growing plants attacked naturally or in cultures which were carried for 8 years on vines or cherries.

Leonian & Lilly (1938) and Westergaard & Mitchell (1947) have emphasised the importance of nutrition in the production of the perfect stage of fungi. Media containing nitrate nitrogen was used because nitrate offered better nitrogen source for the production of perithecia in some fungi.

Hansen & Snyder's (1943) work on *Hypomyces solani* indicated two aspects in perithecia production, namely nutrition and pairing. These approaches were explored.

A. *Nutritional tests:* Cultures were grown on different media, viz., potato dextrose, oatmeal, prune agar, yeast extract in nutrient solution plus glucose, and peptone with nutrient solution plus glucose. These cultures were allowed to grow till they dried up, then flooded with sterile distilled water and left for observations. In some cases this was repeated thrice. In contrast with the findings of Hawker (1936) and Asthana & Hawker (1936) no perithecia were obtained. In a couple of cases coremia appeared. Some cultures were scratched with a sterile needle but this also had no effect.

B. *Pairing:* Isolates No. 1, 2, 3, 4, 5, 6, 7, and 8 were tried in all combinations on the media mentioned under nutritional tests (A) as well as under nutrient medium with various vitamin combinations plus glucose. Isolate number 6, *R. linderae,* which produces perithecia in cultures was used as a check. Two replications were used in each case. Observations were continued for 12 weeks. No fructifications or primordia were noticed on any media or pairs of isolates. Contact of mycelia of different paired isolates produced darkening of the lower hyphae along the line.

Another test was conducted with liquid potato dextrose medium in horizontal 'U' tubes with their ends bent up to retain the solution. Both ends were plugged with cotton. One isolate was inoculated at each end. Nothing characteristic was observed except that the fungus grew as a thick surface mat occasionally sending down peg-like structures into the solution at the margin of the liquid along the walls.

8. GERMINATION OF SPORES

In order to study the viability of conidia, coremia were taken from both inoculated and naturally infected materials and incubated in the laboratory. The coremial suspension containing conidia was variously incubated and poured on plates of plain agar and potato dextrose agar. Drop cultures were tried in oatmeal extract, in water and 2% glucose solution. In none of these experiments was germination of conidia obtained. Thus there is a good reason to doubt that conidia germinate or that they are able to produce infection.

Ascospores also do not germinate so easily. Earlier workers never succeeded in germinating them. In 1937 Hansen, Thomas & Thomas succeeded in germinating them by treating them with 5% lactic acid for 15 minutes and then diluting the suspension with water and plating them on

potato dextrose agar. No experiments were conducted by the writer in this respect.

9. ANTAGONISTIC AND STIMULATORY ACTION OF OTHER ORGANISMS ON *Rosellinia necatrix*

Siblia (1929) grew a strain of *R. glaucum* wit *R. necatrix* and could not detect any stimulation of the growth of *R. necatrix.*

However, there is considerable literature on the antibiotic and stimulatory effects of different organisms on one another, and an attempt was made to see if any of the organisms have such an effect on *R. necatrix.*

Earlier, in experiments on the nutrition with this fungus, it was observed that its growth was very poor on purely inorganic media with glucose. But whenever the fungus was associated with certain bacteria, the growth on such contaminated petri dishes approached normal levels. Similar stimulation of growth of fungus was observed when it was associated with a species of *Penicillium.* The contamination of the fungus cultures with *Aspergillus niger* stopped the growth of the fungus even on potato dextrose. However, if the conditions were kept very humid, the fungus sometimes overcame the detrimental effect of *A. niger* and even covered it, thus showing that the antagonistic action of *A. niger* was not great. This phenomenon of covering the growth of other fungi by *R. necatrix* was particularly striking with *Penicillium* contaminations.

The stimulation was possibly due to the production of some of the nutrient metabolic substances by *Penicillium* which the latter secreted into the medium and which were available to *R. necatrix* through diffusion. These substances may be of the nature of vitamins like biotin, pyridoxines and thiamin for which the fungus is wholly or partially deficient. It may also be due to availability and utilization of certain amino compounds elaborated by *Penicillium.* Another possibility is that some inhibitors present in the medium or produced by *R. necatrix* are neutralized or changed by the *Penicillium* activity. The exact nature of the action remains to be worked out.

The partial inhibition may be due to the non-availability of the required vitamins or amino compounds from the *Aspergillus* or competition for common metabolites, or excretion of some toxic substances or acids by *Aspergillus* to retard the growth of *R. necatrix.*

In order to explore the possibilities of finding some soil organisms capable of inhibiting the spread of the fungus, two isolates (Nos. 11 and 12) of *Trichoderma* were added to *R. necatrix* in liquid potato dextrose cultures,

which were contained in long horizontal U tubes. Two U tubes were connected at both ends by delivery tubes which had a bulb at one end. The bulb was wrapped in wet muslin to set up convection currents. This device for obtaining the circulation of the liquid cultures was suggested by Dr H. N. Hansen. The underlying idea was to set up convection currents by producing a cooling effect at one end of the connecting tubes. The cooling was produced by a wet piece of muslin dipping in a water reservoir as is generally seen in wet and dry bulb thermometer arrangements.

Trichoderma sp. and *R. necatrix* were inoculated in each tube. The slow circulating liquid carried the excreted metabolites of one to the other. The cultures were allowed to grow in this manner for three weeks. The *Trichoderma* isolate No. 11 had no effect on the growth of *R. necatrix* whereas the isolate No. 12 appreciably slowed down the growth of *Rosellinia* and ultimately it almost came to a stand still. These results showed that some isolates of *Trichoderma* excreted certain toxins which were deleterious to the growth of *Rosellinia*.

Moreover the fungicide trials (reported elsewhere) with twig cultures have shown consistently that in a majority of cases whenever this fungus was killed, *Trichoderma* developed on those twigs. These observations hint at the possibility of the crowding out and suppression of *R. necatrix*, once it is weakened by some fungicide or by some suitable *Trichoderma* strains. The inhibition or suppression might have been due to the competition for the metabolites, or to their destruction or conversion into unavailable form or to the excretion of certain compounds inhibiting the otherwise normal utilization of metabolites or inhibiting the functioning of vitamins, amino-acids or other essential enzymes, etc.

SUMMARY

The fungus grows plentifully on dead plant materials but is fastidious when subjected to pure culture conditions. It grows abundantly on complex organic media such as potato dextrose agar, oatmeal agar, yeast and peptone extracts but makes negligible growth on Czapek's and Hoagland's solutions plus dextrose in agar. On prune agar the growth was appressed, silky and sparse.

The fungus needs an external supply of biotin and apparently some pyridoxine and thiamine also. None of the other vitamins tried are needed by it. It has not shown any appreciable growth on any of the carbohydrates tried, except starch, maltose and to some extent glycogen, even in the presence of pyridoxine. Dextrose and sucrose invoked poor response. Amino-acids as sources of nitrogen in the presence of pyridoxine did not permit growth. Even arginine and asparagine had little effect.

The fungus can tolerate a pH range of 3.8-7.8 and grows best at pH 5.8.

R. necatrix is killed at 34°C within 9 days. Optimum for the fungus is 22-25°C. At 0°C it does not grow but remains viable. It can stand desiccation over long periods. Tests have shown that the fungus remained viable for at least a period of 15 months without water. Under very moist conditions the fungus can spread on the surface of water from the infected material to a distance of several inches.

Attempts made to produce perithecia by pairing and cultural treatments viz., supply of vitamins, complex organic materials, amino-acids and carbohydrates, changes in daily temperature, and changes in humidity (desiccation changing to humid conditions), gave negative results.

On inorganic media where the fungus would not normally grow, a contamination by *Penicillium* provided necessary substances (probably biotin, pyridoxine and thiamin) for normal growth. However, certain isolates of *Trichoderma* had inhibitory effect even in potato dextrose solutions.

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APPENDIX

TABLE 1. Showing the average radial growth of *R. necatrix* in cms.

Medium	*Isolate No.*	*Period of incubation*			
		2 days	4 days	7 days	11 days
Potato dextrose agar	1	0.9	2.0	4.6	8.1
	2	0.82	2.05	4.82	8.2
	3	0.7	1.92	4.67	8.3
	4	0.6	1.92	4.22	8.4
	5	0.95	2.35	4.9	8.4
Oatmeal agar	1	0.77	2.22	5.01	8.72
	2	0.62	2.07	5.07	8.7
	3	0.75	2.42	5.26	8.6
	4	0.7	1.92	5.02	8.7
	5	0.88	2.3	5.9	8.72
Prune agar	1	0.42	1.4	3.15	4.62
	2	0.5	1.5	3.4	4.8
	3	0.3	1.55	3.3	5.0
	4	0	1.35	3.0	4.65
	5	0.47	1.35	3.42	4.8
Czapek's agar	1	0	0.33	0.87	1.1
	2	0	0.6	1.4	1.6
	3	0	0.63	1.36	1.6
	4	0	0.46	1.36	1.86
	5	0	0.33	1.33	1.76

TABLE 2. Showing the daily growth rate of isolate No. 2 in cms.

Time	*Potato dextrose*	*Oatmeal*	*Prune*	*Czapek's*
2 days	0.4	0.31	0.25	0
4 ,,	0.61	0.725	0.5	0.15
7 ,,	0.92	1.0	0.63	0.23
11 ,,	0.84	0.9	0.35	0.05

TABLE 3. Showing the radial growth of isolate No. 2 in cms. on different media

Time	*Peptone*	*Nutr.*	*Agar*	*Yeast Extr.*	*Nutr.*	*Agar*	*Malt Extr.*	*Nutr.*	*Agar*
4 days	2.86	2.8	3.0	3.1	3.0	3.2	3.3	3.3	3.0
7 ,,	4.4	4.4	4.9	6.0	5.7	5.6	6.0	6.4	5.4
11 ,,	6.5	6.8	7.3	8.4	8.1	8.4	8.0	8.6	7.9

TABLE 4. Showing daily growth rate of isolate No. 2 in cms. on different media

Time	*Peptone*	*Nutr.*	*Agar*	*Yeast Extr.*	*Nutr.*	*Agar*	*Malt Extr.*	*Nutr.*	*Agar*
4 days	0.71	0.7	0.75	0.77	0.75	0.8	0.82	0.82	0.75
7 ,,	0.51	0.5	0.5	0.96	0.86	0.83	0.92	0.90	0.8
11 ,,	0.50	0.6	0.6	0.6	0.67	0.62	0.5	0.55	0.62

TABLE 5. Showing radial growth in cms. on inorganic media plus glucose.

Medium	*Isolate No.*	*Period of incubation*	
		16 days	25 days
Hoagland's Solution plus 25 gms. glucose in agar.	2	1.4	1.7
	3	1.1	1.0
	5	0.7	2.1
	7	1.1	1.2
	8	1.3	1.5
Czapek's Solution plus 30 gms. sucrose in agar.	2	1.96	2.2
	3	1.7	1.86
	5	1.6	1.86
	7	1.89	1.9
	8	1.1	1.25
Czapek's Solution plus 25 gms. glucose in agar.	2	0.6	1.5
	3	0.96	1.8
	5	0.91	1.5
	7	1.1	1.8
	8	1.0	1.3

TABLE 6. Showing radial growth in cms. on different carbohydrates.

Name of carbohydrate	*Period of incubation in days*								
	4		7		11		21		
l-arabinose	0	0	0	0	0	0	0	0	
Xylose	0	0	0	0	0	0	0	0	
Dextrose	0	0	0.5	Cont	2.5	...	6.6	...	
d-levulose	0	0	0	0	0	0	0	0	
d-galactose	0	0	0	0	2.5	0	6.1	0	one sector
d-mannose	0	0	0	0	0	0	0	0	
maltose	...	...	...	...	6.3	4.1	8.3	8.3	
lactose	...	...	...	...	1.9	1.1	2.9	6.3	
sucrose	...	...	...	...	2.5	Cont	5.4	...	
raffinose	0	0	0	0	3.5	0	7.1	0	
glycogen	1.2	1.6	2.6	3.0	3.3	4.4	6.0	Cont	
starch	...	...	...	...	4.4	4.2	8.5	6.3	
dextrin	...	...	...	...	1.8	0	2.6	0	
gum acacia	0	0	0	0	0	0	0	0	
quince sawdust plus nutr. sol. in agar.	3.0	2.1	4.4	4.3	6.7	6.4	...	...	
quince sawdust plus nutr. sol. dextrose in agar.	2.2	2.8	4.3	4.9	6.8	7.4	...	...	

... = No observations Cont. = Contaminated.

TABLE 7. Showing radial growth in cms. of different nutrient media containing vitamins.

Vitamin	*Isolate No.*	*Period of incubation in days*		
		6	8	11
Thiamine	2	2.9	4.3	6.4
	3	2.3	3.2	5.2
	5	2.4	3.5	5.9
	8	0	0	0
Pyridoxine	2	2.6	4.0	6.3
	3	2.5	3.8	6.3
	5	2.6	3.8	5.9
	8	0	0	0

TABLE 7. *Continued.*

Vitamin	*Isolate No.*	*Period of incubation in days*		
		6	8	11
Biotin	2	2.8	4.2	6.0
	3	2.8	4.2	6.2
	5	2.9	4.2	5.9
	8	3.1	4.2	5.8
Mixture of above three	2	3.0	4.6	6.6
	3	2.8	4.4	6.3
	5	3.0	4.6	6.7
	8	2.6	4.0	5.7

TABLE 8. Showing the radial growth in cms. of different isolates on nutrient medium containing biotin potato-dextrose.

Medium	*Isolate No.*	*Period of incubation in days*		
		5	8	11
Biotin	2	2.5	5.3	7.8
	5	2.35	5.1	7.6
	8	2.1	4.0	6.0
Potato-dextrose	2	2.5	6.3	9.0
	5	3.15	7.0	8.4
	8	2.6	5.7	8.5

TABLE 9. Showing the effect of storage and desiccation on the viability of the fungus.

Test A			Test B		
Period of storage at 25-28°C.	Moisture content of twigs.	Viability	Period of storage	Moisture content of bits	Viability
0 months	45.0 %	Fresh growth	0 month	48.0 %	Fresh growth
2 ,,	27.6 ,,	All Viable	2 ,,	12.95 ,,	Viable
4 ,,	15.0 ,,	,, ,,	3 ,,	9.32 ,,	,,
6 ,,	8.25 ,,	,, ,,	6 ,,	6.0 ,,	,,
9 ,,	9.6 ,,	,, ,,	9 ,,	5.8 ,,	,,
12 ,,	4.4 ,,	2.4 ,,			
15 ,,	4.0 ,,	2 ,,			

5 Contaminated, viability low.

TABLE 10. Showing the effect of pH on the radial growth of the fungus measured in cms.

Isolate No.	*pH used*	*Period of incubation in days*		
		4	6	8
2	2.8	1.4	2.7	4.8
	3.8	2.9	4.6	6.0
	4.8	3.2	5.3	6.6
	5.8	3.8	5.9	8.0
	6.8	3.8	5.9	7.8
	7.8	3.4	5.7	7.0

TABLE 10. *Continued.*

Isolate No.	*pH used*	*Period of incubation in days*		
		4	6	8
3	2.8	1.5	3.0	...
	3.8	3.0	4.9	...
	4.8	3.5	5.3	...
	5.8	3.7	5.6	...
	6.8	4.8	5.8	...
	7.8	3.7	5.7	...
5	2.8	1.1	2.1	3.5
	3.8	2.5	4.7	6.5
	4.8	3.3	5.3	6.9
	5.8	4.0	5.6	7.9
	6.8	4.3	5.6	7.9
	7.8	3.7	5.0	6.4
7	2.8	1.0	2.4	4.0
	3.8	2.9	4.8	6.2
	4.8	3.4	5.4	6.8
	5.8	3.5	5.6	8.3
	6.8	3.6	5.6	7.5
	7.8	3.4	5.2	6.5
8	2.8	1.3	1.8	...
	3.8	1.8	2.8	...
	4.8	2.6	4.0	...
	5.8	3.7	4.7	6.5
	6.8	2.9	5.2	6.2
	7.8	2.4	3.8	4.8

TABLE 11. Showing the final pH of the medium after 35 days.

Initial pH	*Final pH*	
2.8	3.0	Little mycelial growth.
3.8	3.6	
4.8	8.4	
5.8	8.4	
6.8	8.4	
7.8	8.4	

TABLE 12. Showing the radial growth in cms. of isolate No. 1 at different temperatures.

Temp.	*Period of incubation in days*										
	2	4	7	9	11	13	15	20	22	24	26
0°C	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0.2	0.35		0.9	1.25
10	V.l	0.7	1.1	1.65	2.1	2.6	2.85	4.3		5.1	
13	V.l	0.7	1.4	1.8	2.25	2.7	3.45	5.9	8.3		
16	V.l	0.7	1.8	2.65	3.65	4.2	5.05	7.75			
19	V.l	1.05	3.55	4.65	6.05	6.65	8.3				
22	0.45	1.45	3.6	4.95	7.35	8.5					
25	0.65	1.7	3.8	5.25	6.5	8.4					
28	0.65	1.85	3.55	5.35	7.0	8.0					
31	0	0	0	0	0	0					
34	0	0	0	0	0	0					
40	0	0	0	0	0	0					

V.l = Very little growth.

Morphology of the tail fin in the Ophicephalidae

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The literature relating to the tail fin of fishes is very extensive. The morphology and the endoskeletal structure of the tail fin of many fishes have been studied by different workers primarily because of the evolutionary significance of this appendage. It is surprising that the endoskeletal structure of the caudal fin of the Ophicephalidae has so far been neglected almost completely. Bhatti (1952) made a general study of the development of the tail fin of some teleost fishes including the Ophicephalidae, but apart from a brief abstract, no account of his findings is available.

The present paper deals with the endoskeletal structure of the tail fin of four fishes belonging to the Ophicephalidae. The fishes studied are *Ophicephalus striatus* Bloch, *O. marulius* Hamilton, *O. punctatus* Bloch and *O. gachua* Hamilton. An attempt has been made to ascertain the degree of specialization attained by the tail fin and the correlation of its endoskeletal structure with the habit of the fish.

The present study was undertaken, at the suggestion and under the supervision of Dr Hamid Khan Bhatti, at the Zoological Laboratories, Government College, Lahore. I am greatly indebted to Dr Bhatti for his help and encouragement.

MORPHOLOGY

In all the fishes, the tail fin is round, one lobed and continuous with the dorsal and anal fins. The lateral line is straight and reaches the end of the body. The last two vertebrae form the basis for the support of the tail fin. A typical urostyle is absent. The posterior dorsal end of the last vertebra becomes slightly prolonged upwards and backwards, forming a cuplike cavity. In *O. striatus* (fig. 1) and *O. marulius* the proximal end of the last hypural is inserted in this cavity. In *O. gachua* (fig. 2) and *O. punctatus* (fig. 3), however, the proximal tips of the last two hypurals are lodged in it. This posterior dorsal process of the last vertebra is comparatively shorter in the last two fishes. In *O. striatus*, *O. marulius* and *O. gachua* there are a pair of bones just above the last vertebra and closely applied to it. The proximal parts of these bones run parallel to the pro-

cess of the last vertebra and protect the posterior end of the spinal cord; their distal parts turn upwards and enclose the anterior portion of the second dorsal radial (*D. R. 2*). In *O. gachua*, however, they are shorter than in others. The epaxial elements are three in number the first of which is a slender rod-like epural fused with the centrum of the penultimate vertebra. The remaining two are dorsal radials in all cases execept *O. punctatus*. Of these the first dorsal radial is a slender rod-like bone but the second dorsal radial is much flattened and resembles the hypural next to it. In *O. punctatus*, there is only one dorsal radial and the place of the second dorsal is occupied by a second epural attached to the last vertebra. Hypaxially, in all the fishes, there is one radial at the ventral border of the fin and six hypurals, of which the rod-like first hypural is attached to the penultimate vertebra. The remaining five hypurals are much flattened. The second hypural is attached to the ventral side of the last vertebra, which bears two lateral processes at its proximal end. These processes point upwards and backwards extending up to the base of the fourth hypural and making an angle of about 50° with the longitudinal axis of the second hypural itself. Such processes are, however, absent in *O. gachua* and *O. punctatus*. The third, fourth and fifth hypurals are attached to the posterior side of the last vertebra. In *O. striatus* and *O. marulius*, the last hypural (*HY. 6*) is, as mentioned earlier, inserted into the cavity of the process of the last vertebra, while in *O. gachua* and *O. punctatus* the fifth and sixth hypurals (*HY. 5 & 6*) are inserted into the said cavity. There is no distinct grouping of the hypurals, but the ventral blood vessels run between the fourth and fifth hypurals, thus separating the two groups of the hypaxial elements. There are 21 fin-rays in *O. striatus*: 8 epaxial and 13 hypaxial. The fin-rays become gradually shorter from the middle to the borders of the fin. In *O. marulius* the fin-rays are 20 in number, 7 of which are epaxial and 13 hypaxial. In *O. gachua* and *O. punctatus*, there are 18 fin-rays of which 6 are epaxial and 12 hypaxial. In all cases the first epaxial and first hypaxial fin-rays are unjointed and unbranched while the rest are jointed and branched or unbranched. The arrangement and distribution of the fin-rays have been shown in the figures.

DISCUSSION

It has been observed that in the fishes of the family Ophicephalidae the process of the last vertebra (*UR.*) represents the much reduced urostyle. The pair of bones lying above the last vertebra in *O. striatus*, *O. marulius* and *O. gachua* are unusually long and, by virtue of their position and function, represent the bones of the neural arch (*N. A. L.*) of that vertebra. Their distal parts enclose the major portion of the second dorsal radial and this seems to be a secondary condition. The failure of the two

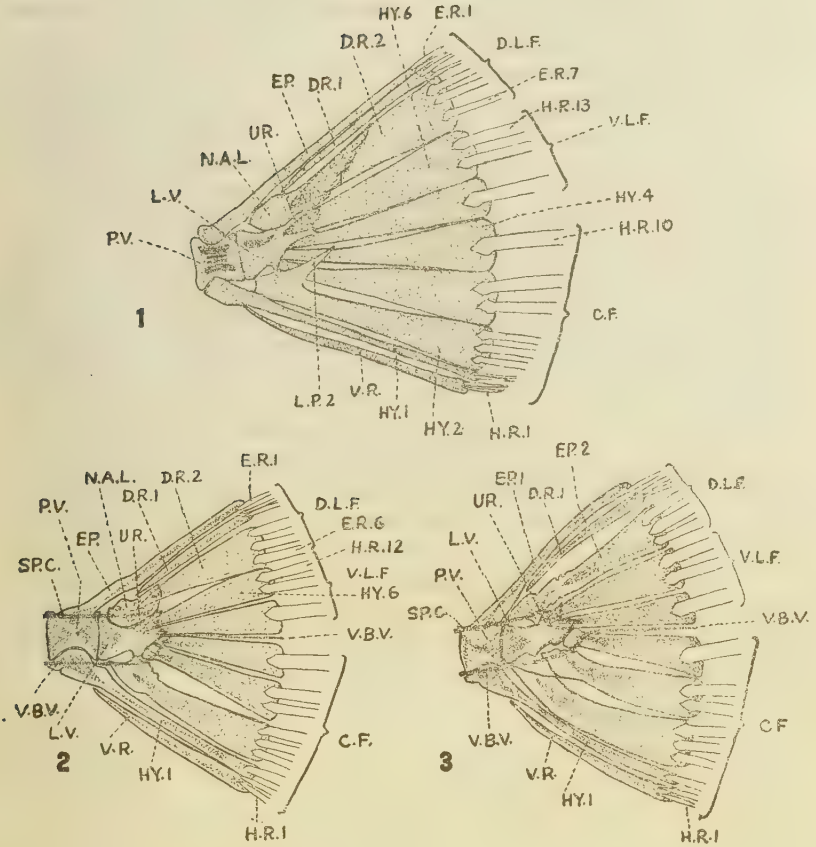

Fig. 1. Tail fin of *Ophicephalus striatus* Bl., side view x 1. Fig. 2. Tail fin of *O. gachua* Ham., side view x 3.5. Fig. 3. Tail fin of *O. punctatus* Bl., side view x 3.5.

C. F., true caudal fin ; *D. L. F.*, dorsal longitudinal fin ; *D. R. 1.*, first dorsal radial ; *D. R. 2.*, second dorsal radial ; *EP.*, epural ; *EP. 1*, *EP. 2*, first and second epurals ; *E. R. 1*, *E. R. 6*, *E. R. 7*, first, sixth and seventh epaxial fin rays ; *H. R. 1*, *H. R. 10*, *H. R. 12*, *H. R. 13*, first, tenth, twelfth and thirteenth hypaxial fin rays ; *HY. 1*, *HY. 2*, *HY. 4*, *H.Y. 6*, first second, fourth and sixth hypurals ; *L. P. 2*, lateral process of second hypural : *L. V.*, last vertebra ; *N. A. L.*, neural arch of last vertebra ; *P. V.*, penultimate vertebra ; *SP. C.*, spinal cord ; *UR.*, reduced urostyle ; *V. B. V.*, ventral blood vessel ; *V. L. F.* ventral longitudinal fin ; *V. R.* ventral radial.

bones of the neural arch of the last vertebra to fuse together is due, probably, to the second dorsal radial, which becomes inserted between them. This insertion is due to lack of space consequent on the upturning of the extremity of the body during the heterocercal stage of the development of the tailfin. The spur-like processes of the second hypural in *O. striatus* and *O. marulius* aid in the attachment of the muscles. According to Whitehouse (1910) the greatly reduced urostyle, and the absence of opisthural cartilage and notochord indicate a high degree of specialization, whereas the presence of two dorsal radials, one ventral radial, and five hypurals, all attached to the last vertebral segment, are indicative of a low degree of specialization. So, the tailfin of these three fishes occupies an intermediate position between the highly and lowly specialized homocercal fins. *O. gachua* may be regarded as more specialized than the other two in so far as the bones of the neural arch of its last vertebra are much reduced. In *O. punctatus*, unlike the others, there are two epurals and only one dorsal radial. The second epural (*EP 2*, Fig. 3) occupies a position which, in the other three, is occupied by the neural arch of the last vertebra and the corresponding dorsal radial (*D. R. 2*). It may be concluded that this epural (*EP. 2*) had been formed by the fusion of the second dorsal radial and the neural arch of the last vertebra. This affords a strong proof of the view that the epurals had been formed by the fusion of the neural arches and dorsal radials. *O. punctatus* presents the rare condition of the last vertebra supporting an epural. However, considering the characters it shares with other fishes of the genus, *O. punctatus* may also be regarded as showing an intermediate state of specialization, though in the family Ophicephalidae this species shows the highest degree of specialization.

Three regions can be recognized in the endoskeleton of the tail fin, thus corroborating Graham-Smith's (1936) view that the tail fin of all the Gnathostomous fishes is a product of three fins, namely, a dorsal longitudinal fin, a ventral longitudinal fin and a true caudal fin. The epaxial elements and the fin-rays supported by them represent the dorsal longitudinal fin, the dorsal group of the hypaxial elements with the fin-rays they support represent the ventral longitudinal fin and the ventral group of the hypaxial elements along with the fin-rays supported by them represent tne true caudal fin. The tail-fin being one-lobed, the dorsal and ventral groups of the hypaxial elements are separated by the ventral blood vessels (Bhatti, 1952) which run between the two groups (Figs. 2 & 3).

As all the epaxial and hypaxial elements are attached only to the vertebral column, they can perform free movements. But the most active part in the movement is taken by the dorsal and ventral radials and the

fin-rays supported by them, because they are free from the vertebral column. Due to the absence of a long urostyle, the hypurals do not get strong support and so cannot make constant movements. This has further resulted in the concentration of the anterior ends of the hypurals into the last two vertebrae. Such a tail fin on the flexible posterior part of the body, though incapable of making constant movement, can produce sudden and strong backward thrust, whose forward component is very powerful and can drive the fish onward with great speed.

SUMMARY

The tail fin of Ophicephalidae shows a mixture of the advanced and primitive characters and occupies an intermediate position between the highly and lowly specialized homocercal fins. The formation of epural by the fusion of neural arch and dorsal radial can be seen distinctly. Though one-lobed, the fin is seen to consist of three groups of elements. The correlation of the endoskeletal structure with the habit of the fish has been discussed.

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Uredinales of West Pakistan

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INTRODUCTION

A systematic survey of the rust flora of West Pakistan has not been made so far, and our knowledge of the species found in this vast area is based on a few sporadic collections mainly in the hilly districts. Out of a total of 455 species recorded by Butler & Bisby (1933) from the whole of British India and Burma, only 30 came from the area now comprising West Pakistan. Since then Arthur & Cummins (1933), Sydow & Ahmad (1939), Cummins (1943), Malik & Khan (1944) and Jorstad (1953) have increased the number of species to 86.

In the present Monograph 185 species of rusts have been recorded, 5 of them being new to Science. The form genera, *Aecidium, Uredo, Monosporidium* and *Peridermium,* account for 19 species ; the remaining 166 belong to the 16 genera listed below :

Cerotelium	1	*Melampsora*	8
Chrysomyxa	1	*Phragmidium*	11
Coleosporium	1	*Puccinia*	94
Cronartium	1	*Pucciniastrum*	1
Diorchidium	1	*Pucciniostele*	1
Endophyllum	1	*Ravenelia*	3
Gymnosporangium	3	*Trachyspora*	1
Hyalopsora	1	*Uromyces*	36

The original plan was to include only those species in this Monograph which were collected or examined by the author. However, that would have given a rather incomplete picture of the known rust flora of West Pakistan and thus detracted much from the usefulness of this work. In order to avoid that, a few records have been admitted solely on the authority cited. The few species recorded from Azad Kashmir have also been included here.

The present survey is far from being complete. A glance at the following table will be enough to emphasize the inadequacy of the present survey. It is only to be hoped that the present work will serve to bring out the

wide gaps in our knowledge of the rusts occurring in West Pakistan, and induce some younger man to undertake a complete survey.

Division	No. of species	Division	No. of species
Peshawar	83	Bahawalpur	x
D. I. Khan	1	Khairpur	x
Rawalpindi	45	Hyderabad	10
Lahore	50	Quetta	15
Multan	10	Kalat	x

The various genera have been arranged alphabetically, and so have been the species of each genus. A complete host index has also been added at the end.

The author is indebted to Dr Ivar Jorstad who examined the whole material and supplied some very useful information which has been incorporated in this work. Special thanks are due to him for furnishing a part of the material collected by the Tirich Mir Expedition of 1950.

Unless otherwise indicated, the diagrams of the spores are magnified about 800 times. The author is thankful to Mr Muhammad Shafi for his help in the preparation of the diagrams.

Order : UREDINALES

The Uredinales, or rusts, are obligate parasites on vascular plants. They are highly specialized into biologic races which are confined to certain species of a host genus or even to varieties of a host species. The mycelium is normally intercellular and consists of branched, septate hyphae sending numerous haustoria into the cells of the host. The clamp connections are rare. The teleutospores develop from the terminal cell of a binucleate hypha, become thick-walled and serve for perennation. When first formed each cell is binucleate but ultimately karyogamy takes place and each cell becomes diploid and uninucleate. The teleutospores are single or united into crusts or columns or a compound spore. They may remain within the host tissue or may burst through the epidermis or cuticle. On germination each cell of the teleutospore normally produces a 4-celled promycelium bearing 4 or rarely 2 sporidia. The sporidia are borne on sterigmata and are discharged violently at maturity. In addition pycnia bearing pycniospores, aecia bearing aecidiospores and uredia bearing uredospores, are often developed.

For the sake of convenience, the various spore forms are designated by the Roman Numerals : O for pycnia, I for aecia, II for uredia, III for telia and IV for sporidia.

The Order has been divided into 2, 3 or even 6 families by different

Uredinologists. The present writer follows Dietel (1928) who recognizes only two families.

KEY TO THE FAMILIES

Teleutospores pedicellate, free or variously united but never in the form of layers or crusts ... ... 1. *Pucciniaceae*

Teleutospores sessile, laterally united into layers, crusts or columns ... ... 2. *Melampsoraceae*

Family : PUCCINIACEAE

KEY TO THE GENERA

Promycelium developed from morphological teleutospores
  Teleutospores borne singly
    Teleutospores 1-celled
      Spores with a germ pore ... ... 1. *Uromyces*
      Spores without a germ pore ... ... 2. *Trachyspora*
    Teleutospores 2-celled
      Spores free, the pedicel not gelatinizing at maturity
        Spores with a transverse septum ... ... 3. *Puccinia*
        Spores with a vertical septum ... ... 4. *Diorchidium*
      Spores embedded in a gelatinous mass, the pedicel gelatinizing at maturity ... ... 5. *Gymnosporangium*
    Teleutospores several celled, the cells arranged in a row... ... ... 6. *Phragmidium*
    Teleutospores united laterally to form a hemispherical head borne on a compound stalk ... ... 7. *Ravenelia*
    Teleutospores catenate ... ... 8. *Pucciniostele*
Promycelium developed from morphological aecidiospores ... ... 9. *Endophyllum*

Family : MELAMPSORACEAE

KEY TO THE GENERA

Teleutospores borne singly in the host tissue
  Telia in Ferns ... ... 10. *Hyalopsora*
  Telia in Angiosperms ... ... 11. *Pucciniastrum*
Teleutospores united laterally into long columns emerging through the epidermis ... ... 12. *Cronartium*

Teleutospores in chains ... ... 13. *Chrysomyxa*
Teleutospores united laterally into crusts
Teleutospores in single layer ... ... 14. *Melampsora*
Teleutospores in several superimposed layers
Spores coloured, germinating after a period of rest ... ... 15. *Phakopsora*
Spores colourless, germinating without a period of rest ... ... 16. *Cerotelium*

Cerotelium Arth.

Pycnia subcuticular. Aecia scattered over the entire leaf surface, pseudoperidium irregularly dehiscent. Uredia covered by incurved paraphyses united below into a short pseudoperidium. Uredospores sessile, solitary. Telia erumpent, minute, appearing white on the germination of the spores. Teleutospores 1-celled, borne in 2 or 3 superimposed layers, hyaline, smooth, germinating without a period of rest.

1. **Cerotelium fici** (Cast.) Arth. in Bull. Torrey Bot. Club 29 : 509, 1902. Syn. *Kuehneola fici* (Cast.) Butler in Annal. Mycol. 12: 76, 1914 ; Syd. Monogr. Ured. 3 : 323 ; Sacc. Syll. Fung. XXIII : 790.

Uredia hypophyllous on yellowish spots, distributed over the whole leaf surface, minute, rounded, pulverulent, cinnamon, covered by numerous incurved paraphyses. Uredospores subglobose or ovate, densely echinulate, yellowish brown, 16-26 x 12-18μ ; epispore 1.5μ thick ; germ pores 2-4. Telia not observed.

On leaves of *Ficus palmata* Forsk., Lahore, March 15, 1952 ; Changa Manga ; Sangla Hill, Dec. 12, 1953, II.

Chrysomyxa Unger

Pycnia subepidermal. Aecia, when present, laterally compressed, with a well developed pseudoperidium, rupturing irregularly at the top. Aecidiospores without germ pores. Uredia subepidermal, erumpent, more or less pulverulent, with a thin, readily evanescent pseudoperidium. Uredospores in chains ; epispore hyaline, without germ pores. Telia erumpent, sometimes pulvinate, at first waxy then velvety. Teleutospores in separate chains of three or more spores each, 1-celled, smooth, hyaline, germinating without a period of rest.

1. **Chrysomyxa deformans** (Diet.) Jacz. in Bull. Leningrad Forestry Inst. 83 : 131-149, 1926. Syn. *Barclayella deformans* Diet. in Hedwigia 29 : 266, 1890 ; Syd. Monogr. Ured. 3 : 522 ; Sacc. Syll. Fung. IX : 316 ; Butler & Bisby, p. 56.

On leaves of *Picea morinda* Link, Kurram Valley (Collett).

Coleosporium Lev.

Pycnia subepidermal. Aecia laterally compressed ; pseudoperidium consisting of a single layer of cells, irregularly dehiscent. Aecidiospores without germ pores. Uredia subepidermal, minute, without a pseudoperidium. Uredospores in chains, without germ pores. Telia minute, subepidermal, waxy. Teleutospores laterally united, sessile, 1-celled, becoming 4-celled during germination to produce an internal promycelium, wall very much thickened and gelatinous at the apex.

1. **Coleosporium campanulae** (Pers.) Lev. in Ann. Sci. Nat. Ser. III, 8 : 373, 1847 ; Syd. Monogr. Ured. 3 : 628 ; Sacc. Syll. Fung. VII : 753 ; Arth. & Cummins, p. 399.

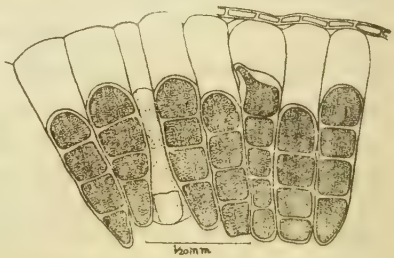
Uredia hypophyllous or caulicolous, scattered or aggregated, minute, orange but soon becoming paler. Uredospores globose, ovate or ellipsoid, densely verrucose, 25-32 x 18-30μ ; epispore hyaline, 1.5μ thick. Telia not observed.

On *Campanula colorata* Wall., Batakundi, Kagan Valley, Aug. 27, 1949 ; Shogran, July 22, 1951 ; Kalam, Swat ; on *C. canescens* Wall., Naran, Kagan Valley, Aug. 25, 1949 ; on *C. evolvulacea* Royle, Kalam, Swat ; Saidpur near Rawalpindi (R. R. Stewart).

The rust appears to be independent of the host alternation and so the telial stage has never been collected.

2. **Coleosporium clematidis** Barcl. in Jour. Asiatic Soc. Bengal 59 : 89, 1890 ; Syd. Monogr. Ured. 3 : 653 ; Sacc. Syll. Fung. IX : 317 ; Arth. & Cummins, p. 399.

Uredia hypophyllous, rarely epiphyllous, on yellowish spots, minute, rounded, yellow or orange, becoming paler. Uredospores subglobose, ovate, ellipsoid or oblong, densely verrucose, 20-30 x 15-20μ ; epispore 2.5μ thick. Telia hypophyllous, scattered or circinate, rounded or irregular, orange but later becoming ochraceous. Teleutospores cylindric to clavate, apex rounded, thickened up to 25μ, hyaline, smooth, 70-95 x 20-25μ



Coleosporium clematidis, teleutospores.

On *Clematis grata* Wall., Upper Topa, Murree Hills, Sep. 21, 1951, III ; on *C. montana* Ham., Lawrence College, Ghora Gali, (R. R. Stewart ; Asghar Ali) ; Gharial (R. R. Stewart).

Cronartium Fr.

Pycnia subepidermal. Aecia, when present, corticolous, vesicle erumpent, large, with a membranous pseudoperidium rupturing irregularly at the apex. Uredia subepidermal, erumpent, covered with an evanescent pseudoperidium. Uredospores solitary, epispore hyaline, without germ pores. Telia formed of rows of spores united laterally into a long waxy column which bursts through the epidermis. Teleutospores 1-celled, smooth, pale coloured, germinating in situ to produce a 4-celled promycelium.

1. **Cronartium ribicola** Fischer in Rabh. Fungi Eur. no. 1595 & Hedwigia 11 : 182, 1872 ; Syd. Monogr. Ured. 3 : 567 ; Sacc. Syll. Fung. VII : 598 ; Malik & Khan, p. 523.

Uredia hypophyllous, surrounded by a delicate peridium which opens at the apex by a pore. Uredospores obovoid or ellipsoid, echinulate, 18-25 x 12-20μ, epispore 2.5μ thick. Telia columnar, cylindric, curved, 2mm. long, yellowish brown. Teleutospores oblong, 70 x 21μ.

On *Ribes rubrum* Linn., Shogran, Kagan Valley, July 22, 1951.

Diorchidium Kalchb.

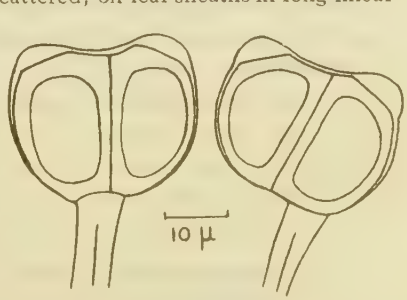
Similar to *Puccinia* but the 2-celled teleutospores are longitudinally septate with a germ pore at the apex of each cell.

1. **Diorchidium digitariae** Ahmad sp. nov.

Soris uredosporiferis hypophylli, minutis, dispersis, foliis seris linearibus, longis ordinatis, pulverulentis, fuscis. Uredosporis globosis, subglobosis vel ovatis, echinulatis, subfuscis, 16-22μ diam. vel 16-24 x 16-22μ, episporis 1.5-3μ crassis, poris germ. 4-8, ordines aequatorialibus vel dispersis. Soris teleutosporiferis similis soris uredosporiferis, nigris. Teleutosporis depressis globosis, septo verticale, apice crassiors (-8μ) 24-32 x 22-26μ, levis, rubro-brunneis ; pedicello subhyalino, persistenti, 110-150μ longo.

Hab. in foliis *Digitari bicorni* (Lamk.) R. & S., Lahore, 3.11.55, no. 13098; typus depositus in Herb. C. M. I.

Uredia hypophyllous, minute, scattered, on leaf sheaths in long linear rows, pulverulent, brown. Uredospores globose, subglobose or ovate, echinulate, pale brown, 16-22μ in diam., or 16-24 x 16-22μ ; epispore 1.5-3 μ thick ; germ pores 4-8, equatorial or scattered. Telia similar, blackish. Teleutospores depressed globose, with a vertical septum, apex thickened up to 8μ, reddish brown, smooth, 24-32 x 22-26 μ ; pedicel nearly hyaline, persistent, 110-150μ long.



Diorchidium digitariae, teleutospores.

On *Digitaria bicornis* (Lamk.) R. & S., Lahore, Nov. 3, 1955, no. 13098, type ; leg. Abdur Rehman.

Endophyllum Lev.

Pycnia subepidermal. Telia subepidermal, like a typical aecium, ultimately becoming cupulate and erumpent, covered by a pseudoperidium. Teleutospores in chains, easily separating, 1-celled, globose, angular or ellipsoid, pale yellowish to brown, without germ pores.

1. **Endophyllum tuberculatum** (Ellis & Kellerm.) Arthur. & Fromme in Bull. Torr. Bot. Club 42 : 58, 1916 ; Sacc. Syll. Fung. XXIII : 849 ; Cummins, p. 448.

On *Lavatera kashmiriana* Camb., Kishenganga Valley (R.R. Stewart).

Gymnosporangium Hedw. f.

Pycnia epiphyllous, subepidermal. Aecia of the *Roestelia*-type. Aecidiospores with numerous, scattered germ pores. Telia erumpent, naked, variously shaped, gelatinous, yellowish or dark chestnut brown. Teleutospores ellipsoid, oblong or rarely fusoid, long-stalked, usually 2-celled, smooth, with 3-7 rarely fewer germ pores in each cell, the wall of the spore and the pedicel swelling in water.

The aecial stage is confined to members of the family Rosaceae while the telial stage is developed on plants of the family Cupressineae.

KEY TO THE SPECIES

Peridial cells very much rugose ; aecidiospores 19-26 x 19-22 μ ; epispore 2.5-3.5 μ ... ... 1. *G. confusum*

Peridial cells rugose or papillate ; aecidiospores 20-24 x 24-29 μ; epispore 2-2.5 μ ... ...2. *G. distortum*

Peridial cells verrucose ; aecidiospores 22-30 x 18-26 μ ; epispore 2.5-3.5 μ ... ...3. *G. clavariaeforme*

1. **Gymnosporangium confusum** Plowr., Monogr. Brit. Ured. p. 232, 1889 ; Cummins, p. 449 ; Syd. Monogr. Ured. 3 : 56.

On *Crataegus oxyacantha* Linn., Kishenganga Valley (R. R. Stewart); on *Cotoneaster vulgaris* Linn., Ziarat, Baluchistan.

The telial stage probably occurs on *Juniperus macropoda* Boiss.

2. **Gymnosporangium distortum** Arth. & Cummins in Mycologia 25 : 400, 1933 ; Cummins in Mycologia 35 : 449, 1943.

On *Cotoneaster bacillaris* Wall., Shogran, Kagan Valley; Kishenganga Valley (R. R. Stewart).

3. **Gymnosporangium clavariaeforme** (Jacq.) DC. Fl. Fr. 2 : 217, 1805 ; Syd. Monogr. Ured. 3 : 59.

On *Cotoneaster integrrima* Medik., *C. nummularia* Fisch & Mey. and *Crataegus oxyacantha* Linn., Kishenganga Valley ; Swat State.

Hyalopsora Magnus

Uredia subepidermal, without a pseudoperidium, but covered by paraphyses. Uredospores of two kinds, sessile, with orange coloured contents and conspicuous germ pores. Teleutospores in one or two layers, produced in subepidermal cells, colourless, divided vertically into 2-4 cells.

1. **Hyalopsora polypodii** (Pers.) P. Magn. in Ber. D. Bot. Ges. 19 : 582, 1901 ; Syd. Monogr. Ured. 3 : 496.

Uredia hypophyllous, scattered, minute, rounded or elliptic, yellowish; paraphyses hyaline, clavate or cylindric-clavate, 35-50 μ long. Thin walled uredospores globose, subglobose or ellipsoid, verruculose, 25-30 x 12-18 μ ; epispore hyaline, 1-1.5 μ thick, germ pores 4, equatorial. Thick-walled uredospores irregular in shape, finely verruculose, 26-32 x 20-24μ, epispore 2-3.5 μ thick, germ pores 6-8, scattered. Teleutospores not observed.

On *Cystopterus fragilis* (Linn.) Bernh., Kagan Valley : Batakundi, August 27, 1949 ; Naran, August 25, 1949 ; Swat State : Kalam, August 1952, II.

Melampsora Cast.

Pycnia subcuticular or subepidermal. Aecia of the *Caeoma*-type, usually without paraphyses. Aecidiospores in chains, verruculose, hyaline. Uredia often minute, orange, pulverulent or subpulverulent, without a pseudoperidium. Uredospores solitary, with indistinct germ pores, intermixed with capitate or clavate paraphyses. Telia subcuticular or subepidermal, forming a firm, black, indehiscent crust. Teleutospores in a single layer, united laterally, coloured, smooth, non-septate or divided by a transverse or oblique septum.

1. **Melampsora euphorbiae** (Schum.) Cast. Obs. Fl. Acotyl. 2, p. 18, 1843. Syn. *M. helioscopiae* Wint. in Rabenh. Krypt. Fl. Ed. 2, I. 1, p. 240, 1882 ; Syd. Monogr. Ured. 3 : 377 ; Sacc. Syll. Fung. VII : 586 ; Malik & Khan, p. 523 ; Jorstad, p. 73 ; Butler & Bisby, p. 60.

Uredia amphigenous or caulicolous, scattered or circinate, yellowish. Uredospores globose, subglobose or ellipsoid, echinulate, yellowish, 17-19x 12-17μ ; paraphyses capitate, thick walled, 14-18μ thick at the apex. Telia subepidermal, amphigenous, brownish black or black. Teleutospores

cylindric-prismatic or oblong, apex not thickened, yellowish brown or brown, 35-65 x 10-15μ.

On *Euphorbia helioscopia* Linn., Lahore; Rawalpindi; Lyallpur; Peshawar (Shaw); Wazirabad (Miller); *E. dracunculoides* Lamk., Chillianwala; Lahore; Lyallpur (Butler); *E. cornigera* Boiss. (=*E. pilosa* var. *cornigera*), Kalam, Swat; Shogran, Kagan; Nathia Gali; *E. hypericifolia* Linn., Murree; *E. thomsoniana* Boiss., Barum Gol : Zapotili; *E. kanaorica* Boiss., Quetta (Asghar Ali).

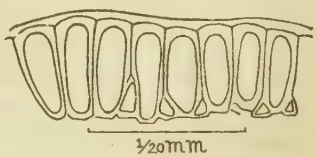
2. **Melampsora euphorbiae-gerardianae** W. Muell. in Centralblatt f. Bakteriol. 17 : 210, 1906; Syd. Monogr. Ured. 3 : 376; Sacc. Syll. Fung. XXIII : 382.

Uredia amphigenous or caulicolous, scattered or circinate, often confluent, pale yellowish. Uredospores globose, subglobose or ellipsoid, echinulate, yellowish, 20-24 x 15-20μ; paraphyses capitate, thickened to 20μ at the apex. Telia subepidermal, blackish brown or black. Teleutospores cylindric-prismatic, apex distinctly thickened, yellowish brown, 45-65 x 10-14μ.

On *Euphorbia falcata* Linn., Khaza Khela, Swat; on *Euphorbia* sp., Hazara (S. A. Malik).

It is closely allied to the previous species but is easily distinguished by the distinctly apically thickened teleutospores.

3. **Melampsora lini** (Pers.) Lev. in Ann. Sci. Nat. Ser. III, 8 : 376, 1847; Syd. Monogr. Ured. 3 : 381; Sacc. Syll. Fung. VII : 588.



Melampsora lini, teleutospores.

Uredia amphigenous or caulicolous, scattered or in groups, covered by the ruptured epidermis, orange. Uredospores globose, subglobose or ellipsoid, verruculose, orange, 18-24 x 14-18μ; epispore about 2.5μ thick; paraphyses capitate, up to 30μ thick at the apex. Telia subepidermal, orange brown then black. Teleutospores cylindric-prismatic, apex not thickened, brown, 40-60 x 12-19μ.

On *Linum usitatissimum* Linn., Kalashah Kaku; Sangla Hill.

Melampsora spp. on Salix and Populus

The various species of *Melampsora* occurring on *Salix* and *Populus* are extremely difficult and practically indistinguishable in their uredo stage. Unfortunately the teleutospores are not present in the material collected by the present writer or in that collected by earlier workers. The authenticity of the various records from West Pakistan is very doubtful. In order

to facilitate future work on this group of species the following key, adapted from Jorstad, is being added.

On **Salix.**

Uredospores small, globose or oblong, evenly echinulate

Teleutospores not thickened apically

Telia subepidermal ... ... *M. epitea*

Telia subcuticular... ... ...*M. ribesii-viminalis*

Teleutospores thickened apically ... ... *M. caprearum*

Uredospores oblong-pyriform, smooth at the apex

Telia subcuticular ... ... *M. allii-fragilis*

Telia subepidermal

Autoecious... ... ...*M. amygdalina*

Heteroecious

Telia hypophyllous... ... ...*M. larici-pentandrae*

Telia generally epiphyllous ... ... *M. salicis-albae*

On **Populus**

Uredospores evenly echinulate

Epispore 1.5-2μ thick

Teleutospores 30-55 x 7-12μ ... ... *M. populnea*

Teleutospores 30-34 x 8-9μ... ... ... *M. ciliata*

Epispore 3-4μ thick... ... ...*M. propinqua*

Uredospores smooth at the apex ; teleutospores

40-70 x 6-10μ... ... ...*M. allii-populina*

4. **Melampsora epitea** (Kze. & Schm.) Thuem., Mitth. Fotstl. Versuchsw. Oesterr. 2 : 38, 1879.

On leaves of *Salix* sp., Shogran, Kagan Valley.

5. **Melampsora salicis-albae** Kleb. in Pringsheim Jahrb. Wiss. Bot. 35 : 679, 1901.

On *Salix acmophylla* Boiss., Khaza Khela, Swat State.

6. **Melampsora larici-caprearum** Kleb. The various records of the species including the one from Kohat in Butler & Bisby, are based on the uredo-stage only. It belongs to *M. caprearum* s. lat. which is characterized by the apically thickened teleutospores.

7. **Melampsora populnea** (Pers.) Karst. Bidr. Kaenned. Finl. Nat. Folk. 31 : 53, 1879. Syn. *M. tremulae* Tul. Ann. Sci. Nat. IV, 2 : 95, 1854. *M. aecidioides* (DC.) Schroet. in Cohn, Krypt. Fl. Schles. III, 1, p. 362, 1887 ; Cummins, p. 449.

On *Populus alba* Linn., Parachinar (I. I. Chaudhuri); Abbottabad (A. H. Khan; R. R. Stewart).

8. **Melampsora ciliata** Barcl. in Jour. Asiatic Soc. Bengal 54 : 223, 1891; Syd. Monogr. Ured. 3 : 343; Sacc. Syll. Fung. XI : 183; Malik & Khan, p. 523.

On *Populus ciliata* Wall., Hazara (S. A. Malik).

Phakopsora Diet.

Pycnia and aecia unknown. Uredia surrounded by pseudoperidium or by incurved paraphyses united below into a short pseudoperidium, opening at the top by a round pore. Uredospores solitary, without germ pores, intermixed with clavate paraphyses. Teleutospores united to form a several layered, subepidermal, dark brown crust.

1. **Phakopsora zizyphi-vulgaris** (P. Henn.) Diet. in Annal. Mycol. 8 : 469, 1910; Sacc. Syll. Fung. XXI : 608; Syd. Monogr. Ured. 3 : 413; Sydow & Ahmad in Annal. Mycol. 37 : 441, 1939; Malik & Khan, p. 524.

Uredia hypophyllous, scattered, minute, long covered by epidermis, ultimately opening by an apical pore, yellowish brown; paraphyses few, hyphal, hyaline, 32-45μ long, 5-7μ broad. Uredospores ellipsoid or ovate, echinulate, yellowish, 18-24 x 13-16μ; epispore about 1μ thick. Telia not observed.

On leaves of *Zizyphus jujuba* Lamk., Lahore, Jan. 28, 1940 & April 8, 1950; Changa Manga, Feb. 18, 1950; *Z. nummularia* W. & A., Chillianwala, June 7, 1934; Bhalike; *Z. sativa* Gaertn. (=*Z. vulgaris* Lamk.), Hazara (S. A. Malik).

Phragmidium Link.

Pycnia, when present, generally epiphyllous, subcuticular. Aecia without a pseudoperidium (*Caeoma* type), but covered by paraphyses; aecidiospores with numerous scattered germ pores. Uredia, when present, covered by paraphyses. Uredospores solitary, globose to ellipsoid or oblong, with numerous scattered germ pores. Telia minute or large, dark coloured, pulverulent or compact. Teleutospores 2-to several-celled, with usually 2-4 germ pores in each cell; pedicel swelling in water or not; epispore thick, laminate, smooth or coarsely verrucose.

On **Rosa**

1. **Phragmidium butleri** Syd. in Annal. Mycol. 5 : 501, 1907; Syd. Monogr. Ured. 3 : 124; Sacc. Syll. Fung. XXI : 725; Arth. & Cumm., p. 401; Malik & Khan, p. 524.

Uredia hypophyllous; paraphyses hyaline, clavate, 50 x 12-16μ.

Uredospores globose, subglobose or ellipsoid, verruculose, 14-20 x 20-28μ, epispore 1.5-2μ thick. Telia hypophyllous, scattered, minute, blackish. Teleutospores cylindric, mostly 5- to 6-septate, rarely 4- or 7-septate, 24-30 x 75-90μ, verrucose; pedicel up to 120μ long, thickened to 25μ at the base.

On *Rosa macrophylla* Lindl., Hazara (S. A. Malik); on *Rosa* sp., Changla Gali (R. R. Stewart); Patriata, Murree Hills, Aug. 16, 1953. II+III.

2. **Phragmidium kamtschatke** (Anders.) Arth. & Cumm. in Mycologia 25 : 401, 1933. Syn. *Puccinia rosae* Barcl. in Jour. Asiatic Soc. Bengal 58 : 233, 1899 (non Schum.). *Gymnoconia rosae* (Barcl.) Liro in Uredineae Fennicae, p.413, 1908. *Telconia rosae* (Barcl.) Syd. in Annal. Mycol. 19 : 168, 1921. *Trolliomyces rosae* (Barcl.) Uelbrich in Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem 14 : 142, 1938. Jorstad, p. 74.

Phragmidium kamtschatke, teleutospores.

Telia amphigenous, confluent and covering the entire surface of the leaflets, pulverulent, ferruginous. Teleutospores 1-septate, oblong or oblong-ellipsoid, apex rounded, not thickened, not or slightly constricted at the septum, base rounded or attenuated, verrucose, yellowish 15-35 x 35-52μ; pedicel hyaline, short.

On *Rosa webbiana* Wall., Barum Valley : Chitral State, leg. I. I. Chaudhuri, June 23, 1950, III.

3. **Phragmidium mucronatum** (Pers.) Schlecht. Fl. Benol. 2 : 156, 1824. *Puccinia rosae* Schum., Enumer. Pl. Saell. 2: 245, 1808. *Phragmidium disciflorum* (Tode) James in Contrib. U. S. Nat. Herb. 3 : 276, 1895; Syd. Monogr. Ured. 3 : 115.

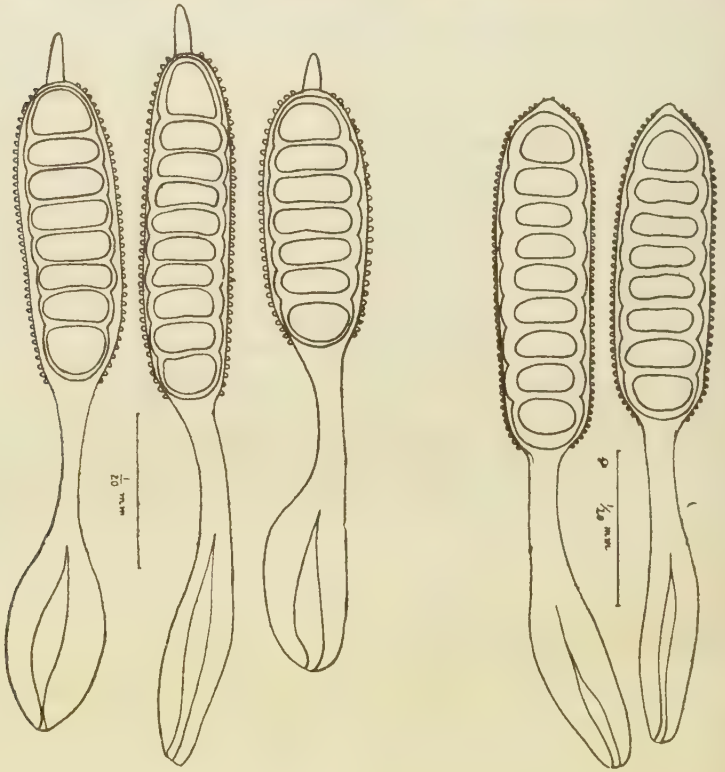
[Aecidiospores 17-20 x 24-28μ, finely verruculose. Uredia hypophyllous, scattered or aggregate; paraphyses clavate, curved, 65 x 12-16μ. Uredospores globose, subglobose or ellipsoid, 15-20 x 25-28μ, minutely verruculose, epispore 2-2.5μ thick. Telia hypophyllous, scattered or becoming confluent, minute or medium, blackish. Teleutospores ellipsoid-oblong to cylindric, 4- to 8-septate, rarely only 3-septate, 26-32 x 60-120μ, apiculus up to 20μ long, verrucose; pedicel as long as the spore, thickened to 30μ at the base.]

On *Rosa* sp., Rawalpindi (R. R. Stewart).

4. **Phragmidium rosae-moschatae** Diet. in Hedwigia 44 : 126, 1905;

Syd. Monogr. Ured. 3 : 125 ; Sacc. Syll. Fung. XXI : 725 ; Malik & Khan, p. 524.

Uredia hypophyllous, scattered, minute, paraphyses hyaline, cylindric-clavate, 12-16 x 35-45μ. Uredospores globose, subglobose or ellipsoid,



Phragmidium rosae-moschatae, teleutospores.

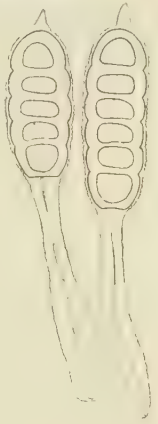
epispore 1.5μ thick, verruculose, 18-20 x 22-25μ. Telia hypophyllous, scattered, minute, blackish. Teleutospores cylindric, 7- to 9-septate, olivaceous brown, 26-32 x 75-100μ, densely verrucose, apiculus minute or up to 25μ long ; pedicel as long as the spore, thickened to 22μ at the base.

On *Rosa moschata* J. Herm., Murree ; on *R. webbiana* Wall., Patriata, Aug. 21, 1953 ; Changla Gali ; Murree, Aug. 8, 1953.

The present collections resemble somewhat *Phr. fusiforme* Schroet., but have on the average longer apiculus in the teleutospores, viz., up to 25μ. The apiculus is also much longer than described for *Phr. rosae-moschatae* (5-11μ).

5. **Phragmidium tuberculatum** J. Muell., Ber. D. Bot. Gesellsch. 3 : 391, 1885.- Syn. *Phr. egenulum* Syd. in Annal. Mycol. 10 : 263, 1912 ; Syd. Monogr. Ured. 3 : 151 ; Sacc. Syll. Fung. XXIII : 823.

Aecidiospores 18-24 x 20-30μ, densely verrucose. Uredia hypophyllous, scattered, minute. Uredospores globose, subglobose or ellipsoid, echinulate, 20-26 x 24-28μ, epispore 2.5-3μ thick. Telia hypophyllous, scattered or aggregated, minute, blackish. Teleutospores ellipsoid-oblong to cylindric, 3- to 5-septate, 24-28 x 55-85μ, verrucose ; pedicel as long as the spore, thickened to 25μ at the base.



Phragmidium tuberculatum, teleutospores.

On *Rosa webbiana* Wall., Kagan Valley : Batakundi, Aug. 28, 1949, II+III ; Barum Valley : Shokor Shal, leg. Wendelbo, July 7, 1949, 0+I+II+III ; July 17 & 21, 1949, 0+I.

On **Potentilla**

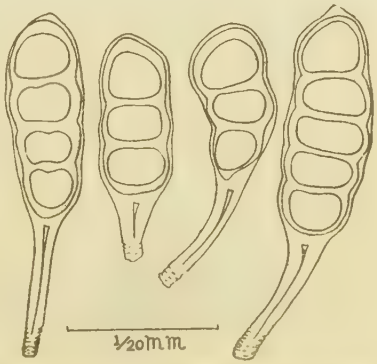
6. **Phragmidium nepalensis** Barcl. in Jour. Asiatic Soc. Bengal 60 : 220, 1891 ; Syd. Monogr. Ured. 3 : 100 ; Sacc. Syll. Fung. XI : 207 ; Malik & Khan, p. 524.

[Uredia amphigenous, usually hypophyllous, aggregate, confluent. Uredospores globose, ovate or irregular, orange, 17-22 x 22-28μ ; paraphyses absent. Telia hypophyllous, scattered, minute, blackish. Teleutospores cylindric, 1- to 4-septate, usually 3-septate, constricted at the septa, apex provided with a minute, inconspicuous papilla, dark brown, 24-26 x 54-68μ ; pedicel as long as the spore, swollen at the base.]

On *Potentilla nepalensis* Hk. f., Hazara (S. A. Malik).

7. **Phragmidium papillatum** Diet. in Hedwigia 29 : 25, 1890 ; Syd. Monogr. Ured. 3 : 99 ; Sacc. Syll. Fung. IX : 315.

Uredia hypophyllous, scattered, minute, yellowish, surrounded by cylindric or clavate paraphyses, 40-55 x 8-12μ. Uredospores globose, subglobose or ellipsoid, minutely echinulate, 14-20 x 18-25μ ; epispore about 2μ thick. Telia hypophyllous, scattered or aggregate, minute, black. Teleutospores ellipsoid or oblong, mostly 3- to 4-septate, sometimes 2-septate, not or very slightly constricted at the septa, rounded at both ends, gradually tapering downwards, epapillate or a minute



Phragmidium papillatum, teleutospores.

(5μ long) papilla present, smooth, brown, 53-94μ long, 28-34μ broad near the apex and 20-24μ at base ; pedicel persistent, hyaline, 30-95μ long, 6-7μ thick.

On *Potentilla nepalensis* Hook. f., Above Kalam : Swat State, August 1953, II+III.

8. **Phragmidium potentillae** (Pers.) Karst. Bidr. Kaenned. Finl. Nat. Folk. 31 : 49, 1879 ; Syd. Monogr. Ured. 3 : 97 ; Sacc. Syll. Fung. VII : 743 ; Arth. & Cumm., p. 401 ; Malik & Khan, p. 524.

Aecidiospores densely verruculose, epispore 2μ thick. Uredia hypophyllous, scattered, minute, yellowish-orange ; paraphyses broadly clavate or capitate, up to 80μ long and thickened to 20μ at the apex. Uredospores globose, subglobose or ovate, finely echinulate, 18-20 x 20-25μ, epispore 1.5-2μ thick. Telia hypophyllous, scattered, blackish. Teleutospores cylindric clavate, usually 2-5 septate, not or slightly constricted at the septum, apex rounded or obtuse, dark brown, 24-28 x 60-80μ, pedicel hyaline, up to 175μ long, thickened to 12μ at the base.

On *Potentilla kleiniana* W. & A., Poonch (R. R. Stewart) ; on *P. argentata* Linn., Astor Valley, Baltistan ; on *P. nepalensis* Hk. f., Hazara (S. A. Malik).

On **Rubus**

9. **Phragmidium barclayi** Diet. in Hedwigia 29 : 264, 1890 ; Syd. Monogr. Ured. 3 : 150 ; Sacc. Syll. Fung. IX : 315.

Telia large, hypophyllous, scattered, black. Teleutospores usually 5-septate, rarely 3-or 6-septate, not constricted at the septa, apex rounded, epapillate, rarely minutely papillate, 28-35 x 70-130μ, nearly smooth or with a few scattered warts, brown ; pedicel hyaline, up to 150μ long, not swelling in water.

On *Rubus lasiocarpus* Sm., Changla Gali, Murree Hills, Sep. 24, 1949, III.

10. **Phragmidium shogranense** Petrak apud Petrak & Ahmad in Sydowia 8 : 162, 1954.

Telia hypophyllous, usually on irregular or orbicular spots, minute or medium, black, pulverulent. Teleutospores cylindric, rounded at both ends, straight or somewhat curved, 3-6, usually 4-5-septate, at septa not

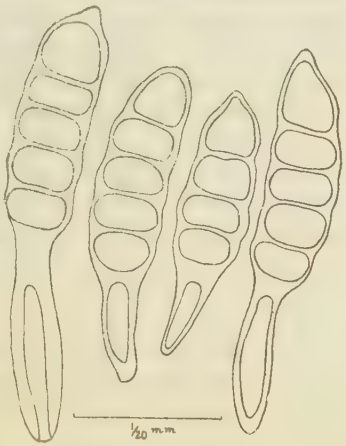
or slightly constricted, pale chestnut brown, epapillate, epispore smooth, 3-6μ thick, 60-115μ, usually about 75-100μ long, 22-30μ, usually 25-27μ broad, pedicel hyaline or pale yellowish brown at the apex, not or slightly thick, 45-130 x 13-17μ.

On leaves of *Rubus* sp., Kagan Valley : Shogran ; Swat State : Miana.

11. **Phragmidium mysorense** (Thirum. & Mundk.) Petr. in Sydowia 8 : 162, 1954. Syn. *Phragmotelium mysorensis* Thirum. & Mundkur in Proc. Ind. Acad. Sci. 15 : 191, 1942.

Telia hypophyllous, black, minute (0.25-0.5mm.) scattered, black. Teleutospores 3- to 5-septate ; 3-septate spores 20-24 x 52-90μ, 4-septate spores 20-24 x 75-85μ, and 5-septate spores 20-24 x 80-100μ, smooth, pale brown, the terminal cell usually longer, each cell with 2 germ pores, epispore 2.5-3μ thick ; pedicel hyaline, not swelling in water, 25-50μ long ; paraphyses numerous.

On *Rubus niveus* Wall., Nathia Gali, Sep. 27, 1949 ; Changla Gali, Sep. 24, 1949 ; Murree, Nov. 7, 1949, III.



Phragmidium mysorense, teleutospores.

Puccinia Pers.

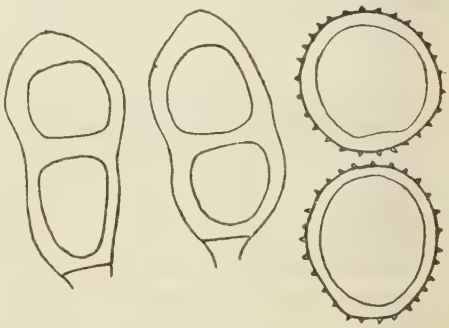
1. **Puccinia absinthii** DC. Fl. Fr. 6 : 56, 1815 ; Syd. Monogr. Ured. 1 : 11 ; Sacc. Syll. Fung. VII : 837.

Uredia hypophyllous, on yellowish or yellowish brown spots, scattered or gregarious, minute, pulverulent, pale brown. Uredospores subglobose, ellipsoid or ovoid, echinulate, yellowish brown, 16-24 x 25-32μ. Telia amphigenous or caulicolous, on the stems confluent and very large, dark brown or blackish. Teleutospores oblong, ellipsoid-oblong or oblong-clavate, apex rounded, thickened (3-7μ), not or slightly constricted at the septum, sometimes slightly attenuated downwards, upper cell verruculose, lower nearly smooth, brown, 15-29 x 39-54μ ; pedicel hyaline, thick, persistent, up to 75μ long.

On *Artemisia persica* Boiss., Barum Valley, Chitral State, leg. I. I. Chaudhuri, July 7, 1950, III ; On *A. parviflora* Roxb., Changla Gali, Oct. 27, 1949, II.

2. **Puccinia acetosae** (Schum.) Koern, in Hedwigia, p. 184, 1876; Syd. Monogr. Ured. I : 581 ; Sacc. Syll. Fung. VII : 638.

Uredia amphigenous, scattered, minute, pulverulent, covered by the ruptured epidermis, ferruginous. Uredospores globose or ellipsoid, aculeate, brown, spines hyaline, 20-24 x 22-28μ. Telia similar. Teleutospores ovoid, ellipsoid or oblong, rounded at both ends or attenuated towards the base, apex not or slightly thickened (to 5μ), slightly constricted at the septum, finely verruculose, chestnut brown, 22-24 x 25-45μ , pedicel hyaline, short.



Puccinia acetosae, uredo- and teleutopores.

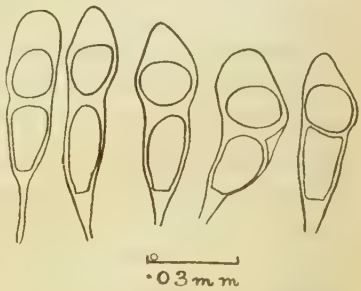
On *Rumex orientalis* Bernh., Kagan Valley : Naran, August 30, 1949, II+III.

3. **Puccinia allii** (DC.) Rud. in Linnaea 4 : 392, 1829 ; Syd. Monogr. Ured. 1 : 614 ; Sacc. Syll. Fung. VII : 655.-Syn. *P. porri* (Sow.) Wint. in Rabenh. Krypt.-Fl. 2, I, 1, p. 200, 1882 ; Butler & Bisby, p. 71.

On *Allium cepa* Linn., Lyallpur (McRae) ; Lahore, II.

4. **Puccinia ambigua** (Alb. & Schw.) Lagh. in Sydow, Uredineen no. 1036, 1897 ; Syd. Monogr. Ured. 1 : 216.

Telia hypophyllous or caulicolous, medium or large, compact, dark brown. Teleutospores clavate, ellipsoid or oblong, apex truncate, rounded or conical, thickened (to 13μ), constricted at the septum, base attenuated, 17-23 x 45-60μ, yellowish brown, the lower cell pale ; pedicel 22-26μ long, hyaline, persistent.



Puccinia ambigua, teleutospores.

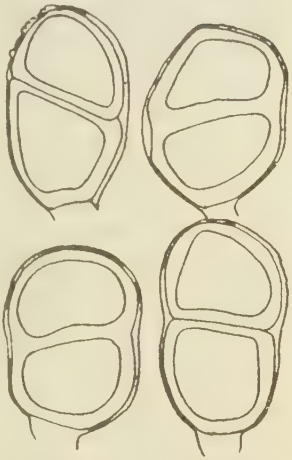
On *Galium aparine* Linn., Ghora Gali, Murree Hills, leg. Asghar Ali, Oct. 29, 1955, III.

The present collection is provisionally referred to *Puccinia ambigua* as it lacks the aecidial stage. In *P. punctata*, recorded from India on *Galium aparine*, uredospores have also been reported in addition to the aecidial stage.

5. **Puccinia angelicae** (Schum.) in Jahrb. Nass. Ver. Nat. p. 52, 1869 ; Syd. Monogr. Ured. 1 : 356 ; Sacc. Syll. Fung. VII : 703.

Uredia hypophyllous, rarely epiphyllous, scattered, yellow-cinnamon, pulverulent. Uredospores obovate to oblong, echinulate, apex thickened up to 10μ ; pale brown, 30-38 x 24-28μ, germ pores 3, equatorial. Telia similar but dark brown. Teleutospores oval or oblong, apex rounded, not thickened, scarcely constricted at the septum, base rounded or attenuated, smooth, brown, 30-40 x 18-25μ ; pedicel hyaline, short, deciduous.

On *Angelica glauca* Edgew., Kalam, Swat State, Aug. 21, 1952, II+III ; Poonch, leg. R. R. Stewart, June 30, 1953.

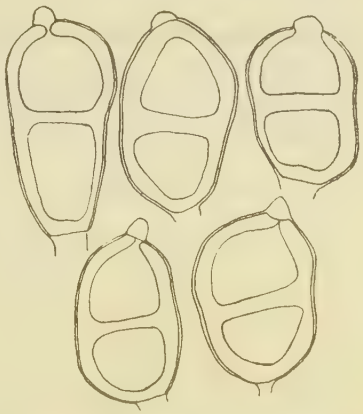


Puccinia angelicae, teleutospores.

6. **Puccinia argentata** (Schultz.) Wint. in Hedwigia 19 : 38, 1880 ; Rabh. Krypt.-Fl. Ed. 2, I, 1, p. 195, 1882 ; Syd. Monogr. Ured. 1 : 450 ; Sacc. Syll. Fung. VII : 639.

Uredia amphigenous, scattered or circinate, on yellowish spots, covered by the ruptured epidermis, pulverulent, ochraceous. Uredospores globose or broadly ellipsoid, finely echinulate, pale yellowish, 11-22 x 15-20μ ; germ pores 4, equatorial. Telia similar but chestnut brown, teleutospores ellipsoid or subclavate, rounded at both ends, apex provided with a colourless papilla, hardly constricted at the septum, smooth, pale brown, 28-32 x 18-22μ ; pedicel hyaline, short.

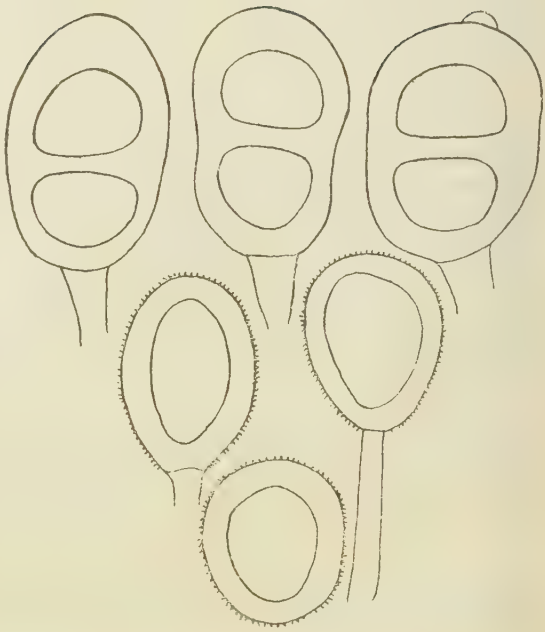
On *Impatiens brachycentra* Kar. & Kir., Kagan Valley : Sharhan, July 24, 1951, III ; Batakundi, Aug. 28, 1949, II+III ; Changla Gali, Sep. 24, 1949, III.



Puccinia argentata, teleutospores.

7. **Puccinia aristidae** Tracy in Jour. Myc. 7 : 281, 1893 ; Syd. Monogr. Ured. 1 : 727 ; Sacc. Syll. Fung. XI : 202.

Uredia hypophyllous, scattered, becoming confluent, covered by the ruptured epidermis, brown. Uredospores globose, subglobose or ovate, aculeate-verruculose, yellowish brown, 25-30 x 22-25μ ; epispore 5μ thick. Telia similar but black. Teleutospores ellipsoid or oblong-ellipsoid, apex rounded or conical, thickened to 10μ, often slightly constricted at the septum, rounded or attenuated at the base, smooth, brown, 36-45 x 25-29μ ; pedicel pale coloured, thick, persistent, up to 50μ long.



Puccinia aristidae, uredo- and teleutospores.

On *Aristida adscencionis* Linn., Rawalpindi, Nov. 7, 1951, II+III.

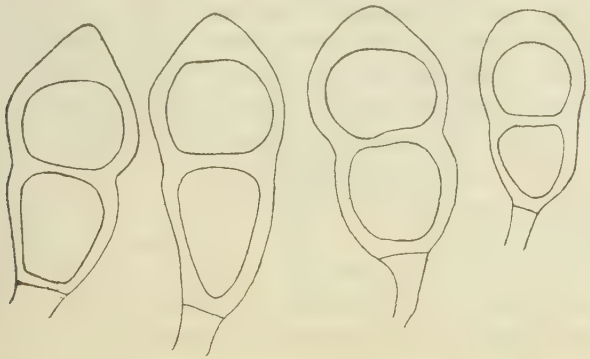
8. **Puccinia barbeyi** (Roum.) P. Magn. in Bot. Zeit. 1883, p. 115 ; Syd. Monogr. Ured. 1 : 618 ; Sacc. Syll. Fung. XVI : 305 ; Arth. & Cummins, p. 402 ; Butler & Bisby, p. 61.

Puccinia barbeyi, teleutospores.

Aecia amphigenous or frequently caulicolous, on yellowish spots. Telia in close association with the aecia, long covered by the epidermis, black. Teleutospores ellipsoid, oblong or oblong-ovoid, rounded at both ends or attenuated at the base, apex sometimes conical, thickened (up to 8.5μ), slightly constricted at the septum, smooth, chestnut brown, 34-56x 23-30μ ; pedicel hyaline, persistent, up to 100μ long.

On *Asphodelus tenuifolius* Cav., very common everywhere, I+III.

9. **Puccinia bithynica** P. Magn. in H. & P. Sydow, Monogr. Ured. 1 : 295, 1904 ; Sacc. Syll. Fung. XVII : 325.



Puccinia bithynica, teleutospores.

Telia hypophyllous, scattered or confluent, surrounded by discoloured yellowish area, up to 1.5 cm. in diameter, compact, persistent, black. Teleutospores clavate or oblong, apex rounded or conical, thickened up to 10μ, constricted at the septum, base attenuated, smooth, dark brown, 32-60 x 16-34μ ; pedicel hyaline, persistent, up to 120μ long.

On *Salvia hydrangea* DC., Hindubagh, Baluchistan, leg. I. I. Chaudhuri, June, 1953, III.

10. **Puccinia bullata** (Pers.) Wint. in Pilze Deutschl. p. 191, 1884 ; Syd. Monogr. Ured. I : 403 ; Sacc. Syll. Fung. VII : 634 p. p.

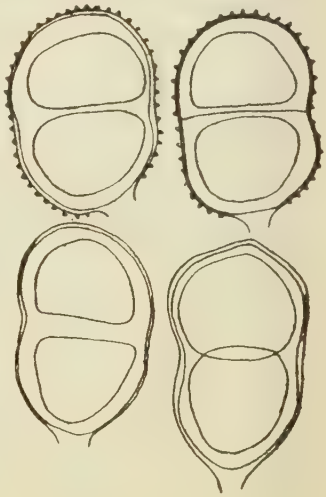
Uredia hypophyllous or caulicolous, on stems linear, usually confluent and large, dark cinnamon. Uredospores globose, subglobose, ovate or ellipsoid, echinulate, brown, apex thickened, 25-40 x 18-28μ, germ pores 3 or 4. Telia similar, dark brown or blackish. Teleutospores ellipsoid or oblong-ellipsoid, apex slightly thickened, slightly constricted at the septum, rounded or attenuated at the base, smooth, brown, 28-42 x 18-32μ, pedicel hyaline, persistent, up to 70μ long.

On leaves and branches of *Peucedanum aucheri* Boiss., Quetta, July 12, 1951, III.

11. **Puccinia butleri** Syd. in Annal. Mycol. 4 : 431, 1906 ; Sacc. Syll. Fung. XXI : 651.

Aecia hypophyllous or caulicolous, usually covering the entire lower surface of the leaf. Uredia amphigenous, covered by the ruptured epidermis, pulverulent. Uredospores globose or subglobose, echinulate, yellowish-brown, 17-25μ in diameter, germ pores 3 or 4. Telia similar but black. Teleutospores ovate, ellipsoid or oblong. apex rounded, not thickened, constricted at the septum, base rounded, verruculose, 30-38 x 20-24μ, pedicel hyaline, deciduous.

On *Launaea aspleniifolia* Hk. f., Sangla Hill ; Lahore, April 15, 1950, I+II+III ; Sargodha ; on *L. nudicaulis* Hk. f., Lahore, Feb. 19, 1952, I+II+III.



Puccinia butleri, teleutospores.

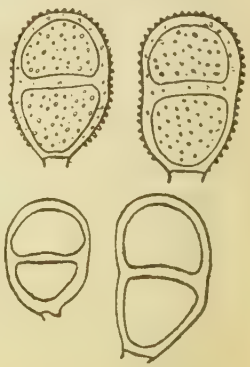
12. **Puccinia calcitrapae** DC. Fl. Fr. 2 : 221, 1805.- Syn. *P. centaureae* DC. Fl. Fr. 5 : 59, 1815 ; Syd. Monogr. Ured. I : 39 ; Sacc. Syll. Fung. XVII : 286 ; Malik & Khan, p. 524 ; Butler & Bisby, p. 65.

Uredia hypophyllous, on yellow spots, scattered, pulverulent, brown. Uredospores globose to ellipsoid, echinulate, brown, 22-30 x 18-26μ, germ pores 3. Telia similar but dark brown. Teleutospores ellipsoid or obovate, rounded at both ends, apex not thickened, scarcely constricted at the septum, minutely verruculose, chestnut brown, 26-28x18-24μ, pedicel hyaline, thin, very short.

On *Centaurea calcitrapa* Linn., Rawalpindi, Feb. 23, 1952, R. R. Stewart, II ; Barikot, Swat State, April 19, 1954, II ; Peshawar (Shaw) ; on *C. phyllocephala* Boiss., Dargai.

13. **Puccinia carduorum** Jacky in Zeitschr. f. Pfl. Krankh. 9 : 288, 1899 ; Syd. Monogr. Ured. 1 : 33 ; Sacc. Syll. Fung. XVI : 297.

Uredia hypophyllous, scattered, cinnamon, pulverulent. Uredospores globose or subglobose, echinulate, pale brown, 24-28μ in diameter ; germ pores 3. Telia similar, dark brown. Teleutospores oblong to ovate, rounded at both ends, apex not thickened, hardly constricted at the septum, verruculose, brown, 25-38 x 16-24μ ; pedicel hyaline, short.



Puccinia carduorum, teleutospores, x 600.

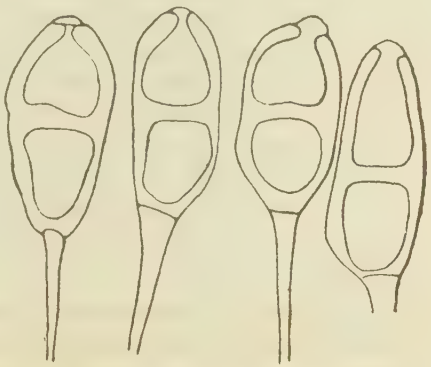
On *Carduus nutans* Linn., Kagan Valley : Batakundi, Aug. 28, 1949; Shogran, July 17, 1951 ; Swat State : Kalam, Aug. 22, 1952, II+III.

14. **Puccinia caricis** (Schum.) Rebent. Fl. neomarch. 1804, p. 356 ; Syd. Monogr. Ured. 1 : 648 ; Sacc. Syll. Fung. VII : 626.

On *Urtica dioica* Linn., Patriata, Murree Hills, Aug. 16, 1953, I.

15. **Puccinia calthae** Link, Sp. Pl. 2 : 79, 1824; Syd. Monogr. Ured. 1 : 540 ; Sacc. Syll. Fung. VII : 624.

Uredia hypophyllous, scattered, pulverulent, chestnut brown. Uredospores globose, subglobose or elliptic, echinulate, pale chestnut brown, 23-29 x 22-24μ ; germ pores 2, in the upper half. Telia similar but dark brown. Teleutospores clavate-oblong or fusoid, apex with a conical papilla, not constricted at the septum, smooth, chestnut brown, 30-42 x 19-22μ, pedicel hyaline, persistent, up to 60μ long.

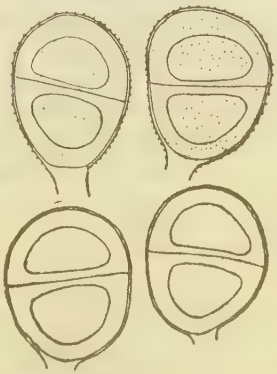


Puccinia calthae, teleutospores.

On *Caltha palustris* Linn., Kagan Valley : Naran, Aug. 15, 1951, II+III.

16. **Puccinia carthami** (Hutzelm.) Corda, Icon. Fung. I, p. 15 ; Syd. Monogr. Ured. 1 : 35 ; Sacc. Syll. Fung. VII : 846.

Uredia amphigenous, usually hypophyllous, scattered, pulverulent, chestnut brown. Uredospores globose or subglobose, sometimes ellipsoid, aculeate, pale chestnut brown, 24-26 x 18-20μ, germ pores 2, equatorial. Telia similar but black. Teleutospores broadly ellipsoid or ovate, rounded at both ends, apex not thickened, not or scarcely constricted at the septum, punctate-verruculose, chestnut brown, 28-40 x 25-30μ, pedicel hyaline, short.

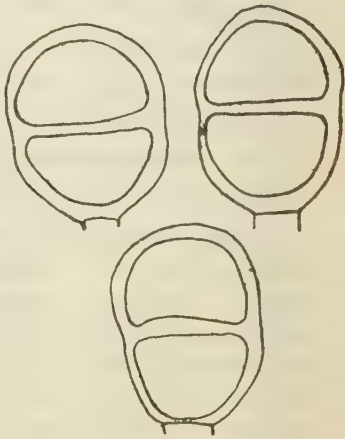


Puccinia carthami, teleutospores, x 600.

On *Carthamus oxyacantha* Bieb., Sangla Hill, March 20, 1952, II+III ; Dargai, April 10, 1954, II ; Swat State : Mingora, Aug. 10, 1952, III ; on *C. tinctorius* Linn., Chillianwala, April 12, 1934, II ; Lahore, April 22, 1935 ; Punjab (Cheema).

17. **Puccinia chitralensis** Jorstad, Nytt. Mag. f. Bot. 1 : 45, 1952.

Pycnia amphigenous. Aecia amphigenous, usually hypophyllous and petiolicolous, intermixed with the teleutospores, ellipsoid or ovate, 27-30 x 19-22μ ; epispore hyaline, echinulate, 1.5-2μ thick, with 3 equatorial germ pores. Telia amphigenous, pulverulent, black. Teleutospores broadly ellipsoid, rounded at both ends, hardly constricted at the septum, 32-39 x 23-26μ, epispore 2-2.5μ thick, not thickened at the apex, chestnut brown, densely and finely verrucoso-striate, pedicel hyaline, deciduous.

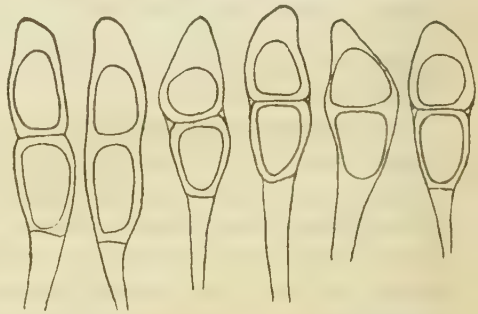


Puccinia chitralensis, teleutospores.

On *Pleurospermum stylosum* C. B. C., Barum Valley : Chitral State, leg. Wendelbo, 0+I+II+III.

18. **Puccinia circaeae** Pers. Syn. Meth. Fung. p. 228, 1801 ; Syd. Monogr. Ured. 1 : 422 ; Sacc. Syll. Fung. VII : 686 ; Malik & Khan, p. 524.

Telia hypophyllous, on yellow or purple spots, scattered or circinate, brown. Teleutospores fusoid, apex rounded or conical, thickened up to 12μ, slightly constricted at the septum, base attenuated, smooth, yellowish brown, 32-40 x 10-13μ ; pedicel hyaline, persistent, smooth, yellowish brown, 32-40 x 10-13μ; pedicel hyaline, persistent, up to 50μ long.



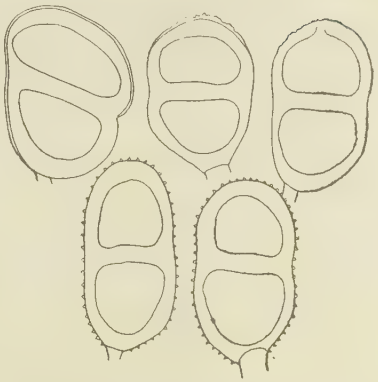
Puccinia circaeae, teleutospores.

On *Circaea alpina* Linn., Changla Gali, August 24, 1949 ; Kagan Valley : Naran, August 25, 1949, III.

19. **Puccinia cirsii** Lasch in Rabh. Fungi Europ. no. 89 ; Syd. Monogr. Ured. 1 : 55 ; Syll. Fung. XVII : 292.

Uredia epiphyllous or usually hypophyllous, on pale spots, scattered, cinnamon. Uredospores globose to ovate, echinulate, pale chestnut brown, 22-28 x 19-24μ, germ pores 3, equatorial. Telia hypophyllous,

similar, dark brown or blackish. Teleutospores ellipsoid or obovate, rounded at both ends, apex not thickened, hardly constricted at the septum, verruculose, chestnut brown, 29-45 x 20-30μ, pedicel hyaline, short.



Puccinia cirsii, teleutospores, x 600.

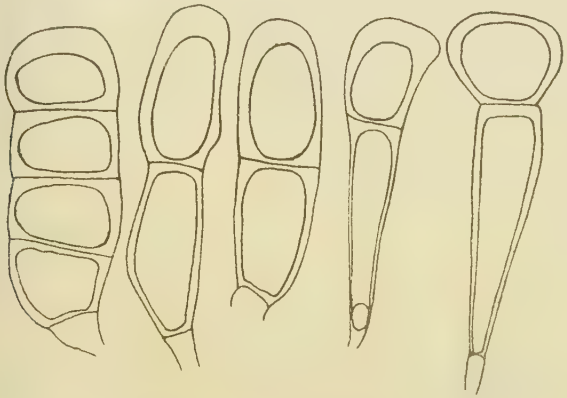
On *Cnicus argyracanthus* C. B. C., Swat State : Madian, Aug. 15, 1952 ; on *Cnicus wallichii* Hk. f., Swat State : Kalam, Aug. 21, 1952; Changla Gali, Sep. 23, 1949, II+III : on *Cnicus* sp., Kagan Valley ; Shogran, July 17, 1951, II.

20. **Puccinia citrulli** Syd. & Butler in Annal. Mycol. 10 : 259, 1912 ; Sacc. Syll. Fung. XXIII : 719.

Uredia amphigenous, without spots, pulverulent, yellowish brown. Uredospores globose or subglobose, echinulate, yellowish brown, 25-30μ in diameter, germ pores 4, equatorial. [Telia similar but dark brown. Teleutospores broadly ovate or ellipsoid-oblong, rounded at both ends, apex not thickened, very slightly constricted at the septum, chestnut brown, verruculose, 38-42 x 24-30μ, pedicel hyaline, up to 30μ long.]

On *Citrullus colocynthis* Schrad. and *C. vulgaris* Linn., Karachi, May 15, 1952, II.

21. **Puccinia clavata** H. & P. Syd. Monogr. Ured. I : 845, 1904 ; Sacc. Syll. Fung. XVII : 356.



Puccinia clavata, teleutospores.

Telia usually hypophyllous, on brown spots, scattered, minute, long covered by epidermis, then erumpent, compact, black. Teleutospores clavate, epex rounded, truncate or conical, thickened up to 10μ, constricted at the septum, smooth, pale brown, apex dark brown, 42-62 x 11-22μ, pedicel hyaline, short.

On *Clematis* sp., Baluchistan : Urak, leg. I. I. Chaudhuri, June 5, 1953, III.

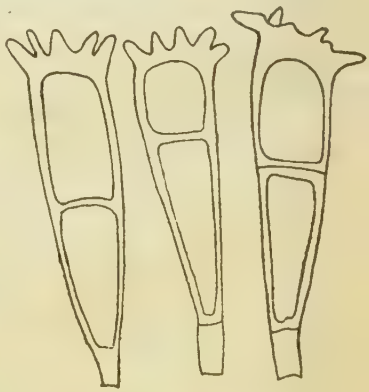
22. **Puccinia collettiana** Barcl. in Sci. Mem. by Med. Officers of the Army of India 5 : 87, 1890 ; Syd. Monogr. Ured. 1 : 226 ; Sacc. Syll. Fung. IX : 306.

Uredia hypophyllous, circinate, brown. Uredospores globose or ovate, brown, echinulate, 28-33 x 21-25μ. Telia epiphyllous, black. Teleutospores oblong, rounded at both ends, apex much thickened, dark brown, smooth, 40-54 x 13-15μ, pedicel hyaline, up to 60μ long.

On *Rubia cordifolia* Linn., Upper Topa, Murree.

23. **Puccinia coronate** Corda, Icon. Fung. I : 6, 1837 ; Syd. Monogr. Ured. I : 699 ; Sacc. Syll. Fung. VII : 623 ; Arth. & Cummins, p. 402 ; Malik & Khan, p. 524. Syn. *P. lolii* Niels. in Ugeskrift f. Landsroend 1 : 549, 1875.- *P. coronifera* Kleb. Zietschr. f. Pfl. krankh. 4 : 135, 1894.

Uredia amphigenous, scattered or in rows, sometimes confluent, minute, orange. Uredospores globose, subglobose or ovate, echinulate, yellow, 20-30 x 16-24μ, germ pores 3-4 ; paraphyses few, intermingled. Telia hypophyllous, often irregularly scattered, long covered by epidermis, black. Teleutospores clavate, not or slightly constricted at the septum, apex provided with apical projections, base attenuated, smooth, brown, 38-50 x 12-17μ, pedicel 5-9μ long ; paraphyses lacking.

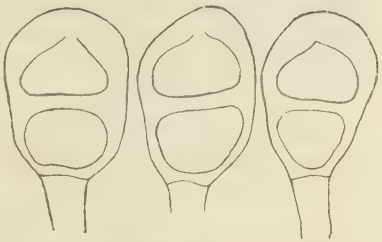


Puccinia coronata, teleutospores.

On *Agrostis pilosula* Trin., Swat State : Kalam, Aug. 22, 1952, II+ III ; on *Rhamnus virgatus* Roxb., Kagan Valley : Shogran, July 15, 1951, I ; on *Rh. dahuricus* Pall, Peshawar Valley, I.

24. **Puccinia cynodontis** Lacroix, Exs. III, no. 655 ; Syd. Monogr. Ured. I : 748 ; Sacc. Syll. Fung. VII : 661 ; Sydow & Ahmad, p. 441.

Uredia hypophyllous, scattered or in rows, minute, yellowish brown. Uredospores globose, subglobose or ellipsoid, finely echinulate, pale brown, 22-25μ in diameter, epispore 2.5μ thick, with 2-3 germ pores. Telia amphigenous or culmicolous, usually hypophyllous, scattered or in rows, black. Teleutospores ellipsoid or oblong, apex thickened up to 18μ, constricted at the septum, base rounded or attenuated, smooth, brown, 30-40 x 20-22μ, pedicel persistent, brownish, up to 50μ long.



Puccinia cynodontis, teleutospores.

On *Cynodon dactylon* Pers., very common throughout the area, II+III ; on *Plantago lanceolata* Linn., Quetta, leg. Asghar Ali, April 8, 1955, I.

"The aecidium on *Plantago lanceolata* belongs to *P. cynodontis*. Among the numerous aecidial hosts of this rust *Pl. lanceolata* is one of the most common. On this host aecidia of *P. cynodontis* have been found in Russian Central Asia and Iran." Jorstad.

25. **Puccinia duthiae** Ellis & Tracy in Bull. Torr. Bot. Club *23* : 283, 1897 ; Syd. Monogr. Ured. I : 726 ; Sacc. Syll. Fung. XIV : 352; Arth. & Cummins, p. 402.

Uredia hypophyllous, scattered, minute, blackish brown. Uredospores globose or subglobose, echinulate, yellowish brown, 27-36μ in diam. ; paraphyses clavate, brown, intermixed. Telia similar but black. Teleutospores elliptic or ovate-ellipsoid, rounded at both ends, apex not thickened, not or very slightly constricted at the septum, smooth, dark brown, 38-46 x 26-32μ, epispores 4-5μ thick, pedicel brown, persistent, up to 120μ long.

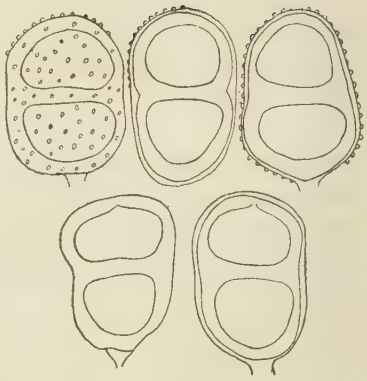
On *Bothriochloa intermedia* A. Camus and *B. pertusa* (Willd.) A. Camus, Sangla Hill ; Rawalpindi ; *Dicanthium annulatum* (=*Andropogon ischaemum* Roxb.), near Mogli Bungalow, Jhelum District (R. R. Stewart).

26. **Puccinia echinopsis** DC. Fl. Fr. 6 : 57 ; Syd. Monogr. Ured. I : 75 ; Sacc. Syll. Fung. XVII : 292.

Uredia amphigenous, without spots, scattered, cinnamon. Uredo-

spores globose, echinulate, pale brown, 24-28μ in diameter ; germ pores 3. Telia similar, black. Teleutospores ellipsoid or oblong-ellipsoid, rounded at both ends, apex not thickened, scarcely constricted at the septum, finely verruculose, pale brown, 34-43 x 20-26μ, pedicel hyaline, short.

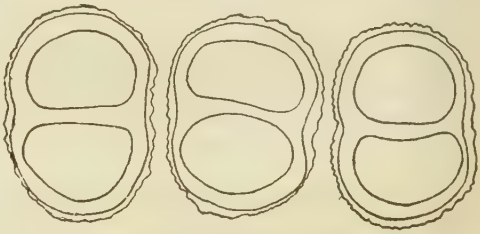
On *Echinops cornigera*, DC., Swat State : Kalam, August 23, 1952, II+ III.



Puccinia echinopsis, teleutospores, x 600

27. **Puccinia eremuri** Kom. in Scrip. Bot. Hort. Univ. Petropol. 4 : 30, 1895 ; Syd. Monogr. Ured. I : 622 ; Sacc. Syll. Fung. XVI : 306.

Telia amphigenous, on yellowish spots, scattered or confluent, long covered by epidermis, dark brown, pulverulent. Teleutospores ovate or broadly ellipsoid, rounded at both ends, apex not thickened, not or slightly constricted at the septum, verruculosely reticulate or longitudinally substriate and covered with minute verrucae, rarely quite smooth, dark chestnut brown, 30-38 x 25-29μ ; pedicel hyaline, short, deciduous.



Puccinia eremuri, teleutospores.

On *Eremurus himalaicus* Baker, Kagan Valley : Batakundi ; on *E. persicus* Boiss., Old Kack Railway station, Baluchistan ; May 1, 1948 ; Quetta, April 22, 1948 ; Ziarat, June 7, 1953, leg. I. I. Chaudhuri, III.

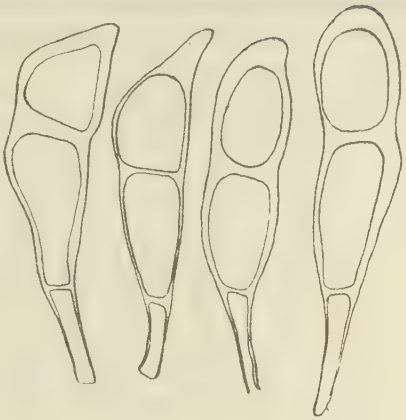
28. **Puccinia extensicola** Plowr. in Monogr. Ured. p. 181, 1889 ; Syd. Monogr. Ured. I : 667 ; Sacc. Syll. Fung. IX : 311 ; Cummins, p. 452.

On *Solidago virga-aurea* Linn., Kagan Valley : Shogran ; Karen (R. R. Stewart).

The uredo- and teleuto-stages, occurring on species of *Carex*, have not been collected within the area.

29. **Puccinia flavipes** Sydow in Annal. Mycol. 5 : 497, 1907 ; Sacc. Syll. Fung. XXI : 684 ; Sydow & Ahmad, p. 440.

Uredia amphigenous, scattered, long covered by epidermis, pale brown, bullate. Uredospores globose, subglobose or ellipsoid, echinulate, pale brown, 18-25 x 12-20μ, epispore 1.5μ thick, with 2 germ pores. Teleutospores intermixed, oblong or clavate or linear, apex rounded, truncate or conical, thickened up to 10μ, not or slightly constricted at the septum, base attenuated, smooth, yellow or yellowish brown, 35-55 x 10-18μ, pedicel yellowish, up to 20μ long.



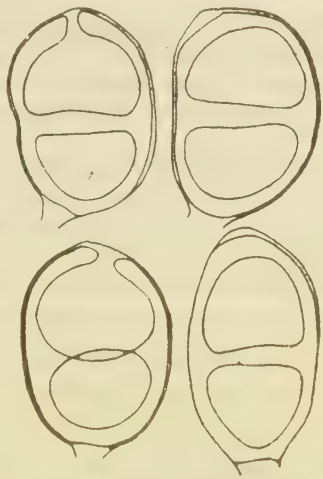
Puccinia flavipes, teleutospores.

On *Fimbristylis dichotoma* Vahl, Chuharkana, April 15, 1952, II+III ; Sangla Hill ; on *F. schoenoides* Vahl, Kalashah Kaku, Gujranwala Distt.

30. **Puccinia gentianae** (Str.) Roehl. in Deutschl. Fl. Ed. 2, III, 2 p. 131, 1813 ; Syd. Monogr. Ured. I : 340 ; Sacc. Syll. Fung. VII : 604.

Uredia amphigenous, scattered or circinate, pale chestnut brown. Uredospores globose, subglobose or oval, aculeate, yellowish brown, 20-30 x 18-24μ, germ pores 2. Telia similar but dark brown. Teleutospores ellipsoid to ovoid, rounded at both ends, thickened at the apex, sometimes with a broad low papilla, not constricted at the septum, smooth, chestnut brown, 20-40 x 22-26μ, pedicel hyaline, long.

On *Gentiana kurroo* Royle, Abbottabad, leg. I. I. Chaudhuri, April 1952, II+III.

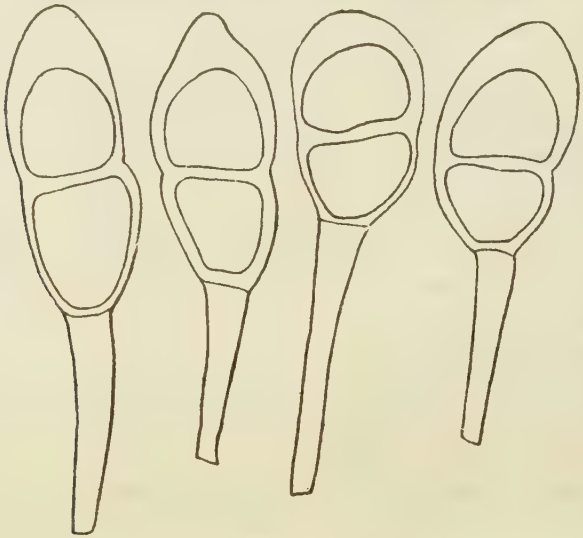


Puccinia gentianae, teleutospores.

31. **Puccinia graminis** Pers. Syn. Meth. Fung. p. 228, 1801 ; Syd. Monogr. Ured. I : 692 ; Sacc. Syll. Fung. VII : 622.- Black Rust.

Uredia hypophyllous, yellowish or brown, paraphyses lacking.

Uredospores elongate-ellipsoid, echinulate, 22-42 x 16-22μ, germ pores 4, equatorial. Telia similar but black and forming long lines, bursting



Puccinia graminis, teleutospores.

rather early. Teleutospores oblong-clavate, narrowed or rounded above, thickened up to 13μ at the apex, slightly constricted at the septum, attenuated below, smooth, chestnut brown, 35-60 x 12-22μ, pedicel brownish, persistent, up to 60μ long ; paraphyses absent.

On *Triticum aestivum* Linn. (=*T. vulgare* Vill.), very common throughout the area ; on *Bromus japonicus* Thunb., Swat State : Miana, Aug. 11, 1952, III ; on *Agropyron semicostatum* Nees, Miana ; Aug. 11, 1952, III ; on *Agrostis munroana* Aitch. & Hemsley, Kagan Valley : Batakundi ; on *Hordeum vulgare* Linn., Sangla Hill; Lyallpur; Sind ; on *Cynodon dactylon* Pers., Quetta, leg. Asghar Ali, III.

32. **Puccinia helianthi** Schw. in Schr. Naturf. Ges. Leipzig 1 : 73, 1822 ; Syd. Monogr. Ured. I : 92 ; Sacc. Syll. Fung. VII : 605.

Uredia hypophyllous, without spots, scattered or in groups, cinnamon, pulverulent. Uredospores globose, ellipsoid or ovate, aculeate, yellowish brown, 22-27μ in diameter ; germ pores 3. Telia similar but compact and dark brown. Teleutospores ellipsoid or oblong, apex rounded or conical, thickened up to 8μ, paler, constricted at the septum, base rounded, smooth, chestnut brown, 37-50 x 22-27μ ; pedicel hyaline, per-

sistent, up to 105μ long.

On *Helianthus annuus* Linn., Rawalpindi, leg. Shaukat Ali, April 13, 1954, II+III.

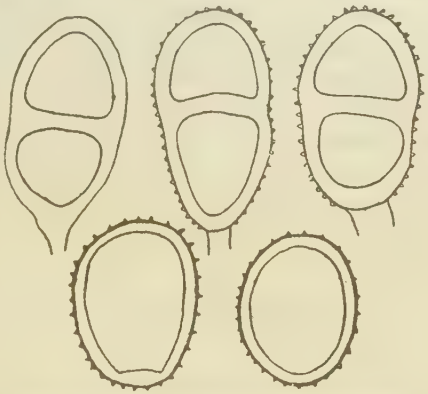
33. **Puccinia heracleicola** Cummins in Mycologia 35 : 452, 1949 ; Jorstad, p. 76.

On *Heracleum thomsoni* C.B.C. var. *glabior* C.B.C., Barum Valley : Chitral State, 0+II+III, leg. Wendelbo.

It is distinguished from other species of *Puccinia* found on *Heracleum* by the coarsely verrucose teleutospores and the apically thickened uredospores.

34. **Puccinia hieracii** (Schum.) Mart. Prodr. Fl. Mosq., Ed. 2, p. 227, 1817 ; Syd. Monogr. Ured. I : 95 ; Sacc. Syll. Fung. VII : 633 p. p.

Uredia amphigenous, usually epiphyllous, on pale spots, scattered, sometimes circinate, soon naked, pulverulent, cinnamon. Uredospores globose or ellipsoid, echinulate, yellowish brown, 24-29 x 16-25μ, germ pores 2, equatorial. Telia similar but dark brown. Teleutospores ellipsoid, rarely ovate, apex rounded, not thickened, scarcely constricted at the septum, base rounded or attenuated, delicately verruculose, brown, 28-40 x 16-24μ, pedicel hyaline, short.



Puccinia hieracii, uredo- and teleutospores.

On *Hieracium vulgatum* Koch, Kagan Valley : Shogran, July 16, 1951, II+III.

35. **Puccinia holboelli** (Hornem.) Rostr. in Fungi Groenl. in Meddle. on Groenl. 3 : 534, 1888 ; Sacc. Syll. Fung. VII : 734 & IX : 292.

Telia hypophyllous, rounded, pulvinate, dark brown. Teleutospores oblong, subclavate or clavate, apex rounded, thickened (to 9μ) constricted at the septum, attenuated towards the base, smooth, brown, 23-35 x 15-24μ, pedicel hyaline, persistent, as long as the spores or shorter.

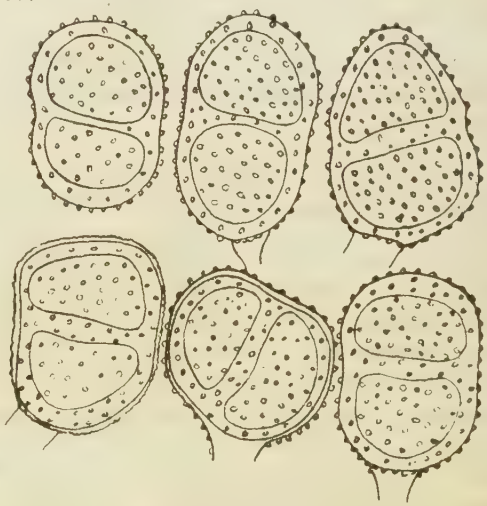
On leaves of *Erysimum hieraciifolium* Linn., Naltar Valley, Gilgit (R. R. Stewart).

In the present collection the size of the spores and pedicels is much smaller than that described by other authors and it may prove to be a distinct species.

36. **Puccinia hysterium** (Str.) Roehl. Deutschl. Fl. Ed. 2, III, 3 : 131, 1813.- Syn. *P. tragopogonis* Corda, Icon. Fung. 5 : 50, 1842.- *P. tragopogi* (Pers.) Wint. in Hedwigia 19 : 44, 1880; Syd. Monogr. Ured. I : 167 ; Sacc. Syll. Fung. VII : 669.

Telia amphigenous, without spots, scattered or in groups, long covered by epidermis, finally naked, pulverulent, dark brown. Teleutospores ellipsoid, rounded at both ends, apex not thickened, slightly constricted at the septum, tuberculate, chestnut brown, 27-40x22-28μ, pedicel hyaline, short.

On *Tragopogon* sp., Kagan Valley : Besal, leg. I. I. Chaudhuri, July 7, 1952, III.



Puccinia hysterium, teleutospores.

38. **Puccinia invenusta** Sydow in Annal. Mycol. 5 : 498, 1907 ; Sacc. Syll. Fung. XXI : 686.

Uredia amphigenous, usually hypophyllous, scattered or in rows, oblong, 0.5-0.8 mm. long, long covered by epidermis, yellowish brown. Uredospores ovate, ellipsoid or pyriform, minutely verruculose, pale yellowish, 18-32 x 12-18μ, epispore 1.5μ thick ; paraphyses intermixed, hyaline, clavate or capitate. Telia similar but black. Teleutospores oblong or clavate, apex rounded or attenuated, up to 5μ thick, not or very slightly constricted at the septum, base attenuated, smooth, brown, 26-40 x 14-20μ; pedicel brown, persistent, up to 60μ long.

On *Phragmites karka* Trin., Lahore, Feb. 13, 1952, II+III.

38. **Puccinia iridis** (DC.) Rabh., Deutschl. Krypt.-Fl., 1. p. 23, 1844 ; Syd. Monogr. Ured. I : 598 ; Sacc. Syll. Fung. VII : 657.

On *Iris germanica* Linn., Lahore, leg. S. L. Ghosh, April 1924, II.

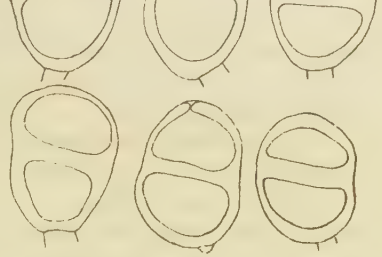
39. **Puccinia isiacae** (Thuem.) Wint. in Kze., Plant. Orient-ross. p. 127, 1817 ; Syd. Monogr. Ured. I : 792 ; Sacc. Syll. Fung. VII : 851.

Uredia amphigenous, large, broadly effuse, up to 6 cm. long, 1.5 cm. broad, pulverulent, ferruginous, at first covered then exposed. Uredospores globose, subglobose or ellipsoid, 18-26μ in diameter, or 18-29 x 16-22μ, nearly smooth, yellowish brown, epispore 5-7μ thick. Telia similar but dark brown. Teleutospores ellipsoid, rounded at both ends, apex thickened up to 9μ, not or slightly constricted at the septum, smooth, yellowish brown, 35-52 x 22-28μ, epispore thick, pedicel hyaline, persistent, up to 160μ long.

On *Phragmites karka* Trin., Quetta, Feb. 22, 1951, II+III ; on *Lepidium draba* Linn., Quetta, leg. Asghar Ali, April 8, 1955, I.

40. **Puccinia jorstadii** nom. nov. Syn.-*P. nitida* Barcl. in Jour. Asiatic Soc. Bengal 59 : 107, 1890, non *P. nitida* (Str.) Roehl; Syd. Monogr. Ured. 1 : 574 ; Sacc. Syll. Fung. IX : 307 ; Malik & Khan, p. 424.

Uredia hypophyllous, on brown spots, scattered, brown, pulverulent. Uredospores globose, subglobose or ovate, echinulate, yellowish brown, 22-25μ in diam., germ pores 2, supra-equatorial. Telia similar but dark brown. Teleutospores ellipsoid or oblong, rounded at both ends, apex not thickened, epapillate, not or very slightly constricted at the septum, smooth, brown, 22-30 x 18-22μ, pedicel hyaline, very short.



Puccinia jorstadii, teleutospores.

On *Polygonum amplexicaule* var. *speciosum*, Swat State : Kalam ; Hazara (S.A. Malik).

As pointed out by Jorstad, *Puccinia nitida* Barcl. must get a new name as it is preoccupied by *P. nitida* (Str.) Roehl. found on members of the family Umbelliferae. The name *P. jorstadii* is therefore proposed for it.

The teleutospores were compared with those of *P. mamillata* from material furnished by Dr E. Mueller. In *P. mamillata* a characteristic apical papilla is always present while in the present species the spores are usually epapillate.

41. **Puccinia junci** (Strauss) Wint. in Hedwigia 19 : 28, 1880 ; Syd. Monogr. Ured. I : 642 ; Sacc. Syll. Fung. VII : 658.

Uredia scattered, elliptic, ferruginous. Uredospores globose, subglobose or ellipsoid, aculeate, pale brown, 16-28 x 15-20μ. Telia scattered,

sometimes confluent, oblong, long covered by epidermis, dark brown. Teleutospores clavate or subfusiform, apex thickened to 10μ, truncate or acuminate, not or slightly constricted at the septum, base attenuated, smooth, pale brown, apex dark brown, 35-40 x 12-20μ, pedicel tinted, persistent, up to 50μ long.

On *Juncus* sp., Baluchistan : Hanna Valley (Asghar Ali).

42. **Puccinia komarovii** Tranzsch. in P. & H. Sydow, Monogr. Ured. I : 451, 1904; Sacc. Syll. Fung. XVII : 350; Arth. & Cumm., p. 403.

Aecidia covering the surface of the leaf petiole. [Uredia hypophyllous, on yellowish spots, scattered or circinate around a larger one, pulverulent, cinnamon. Uredospores subglobose or ellipsoid, echinulate, pale brown, 22-29 x 17-24μ, with a single apical germ pore. Telia similar but chestnut brown. Teleutospores ellipsoid, ovate or subclavate, apex with a hyaline papilla, not or slightly constricted at the septum, smooth, chestnut brown, 27-38 x 18-24μ, pedicel hyaline, short, fragile.]

On *Impatiens* sp., Poonch, June 30, 1953, I ; Changla Gali (R. R. Stewart).

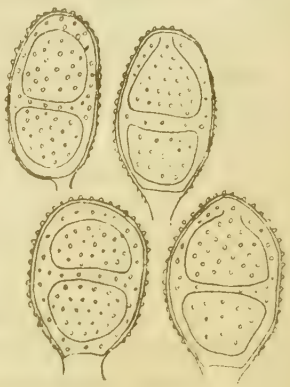
43. **Puccinia kuehnii** (Krueg.) Butler in Annal. Mycol. 12 : 82, 1914 ; Sacc. Syll. Fung. XXIII : 744, 1925. Syn. *Uredo kuehnii* Wakker & Went in De Zeikten van het suikerreit op Java, Leiden 1898, p. 144; Butler & Bisby, p. 69.

On *Saccharum spontaneum* Linn., Lahore ; Lyallpur (A. Khan) ; on *S. munja* Roxb. (=*S. arundinaceum* Hk. f.), Lahore (B. Dass).

The occurrence of this rust within the area needs confirmation as most of these records are probably based on *Uredo ravennae*.

44. **Puccinia leveillii** Mont. ex G. Gay, Hist. Fis. Polit. Chile 8 : 41, 1852 ; Sacc. Syll. Fung. XI : 185. Syn. *P. geranii-sylvaticae* Karst., Not. Sallk. Fl. 8 : 220, 1866; Syd. Monogr. Ured. I : 465; Sacc. Syll. Fung. VII : 682 ; Jorstad, p. 77.

Telia hypophyllous or petiolicolous. in groups or confluent to form large, elongated dark brown masses, the infected leaves much curled. Teleutospores ellipsoid, rounded at both ends, apex not thickened, hardly constricted at the septum, upper cell verrucose, lower less so or nearly smooth, brown, 24-32 x 15-20μ, pedicel hyaline, deciduous.



Puccinia leveillii, teleutospores, x 600.

On *Geranium pratense* Linn., Kagan Valley: Shogran, July 1952, III ; *G. collinum* Bieb.,

Satpura Nallah, Baltistan (R. R. Stewart) ; *G. rectum* Trautv. Kalam ; on *G. collinum* var. *eglandulosum* Ledeb., Barum Valley : Zapotili ; Och Anzog, III.

45. **Puccinia liberta** Kern in Mycologia 11 : 142, 1919 ; Sacc. Syll. Fung. XXII : 720. Syn.-*P. bulbostylidicola* Thirumal. in Mycologia 39 : 239, 1947.

Uredia culmicolous, scattered, sometimes confluent, long covered by epidermis, ultimately opening by a longitudinal slit. Uredospores broadly ellipsoid, finely echinulate, 13-20 x 18-26μ, germ pores 2, equatorial. Telia similar but black and more compact. Teleutospores clavate-oblong or fusiform, apex rounded or acuminate, thickened up to 7μ, base attenuated, smooth, 40-50 x 14-18 μ, pedicel short.

On *Bulbostylis barbata* Kunth., Sialkot.

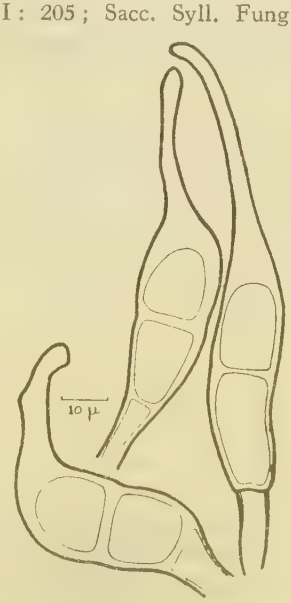
46. **Puccinia ligustica** Ellis & Ev. in Bull. Torr. Bot. Club p. 363, 1895 ; Syd. Monogr. Ured. I : 393 ; Sacc. Syll. Fung. XIV : 303.

On *Selinum papyraceum* C.B.C., Gilgit (R. R. Stewart).

47. **Puccinia longirostris** Kom. Scripta bot. Hort. Univ. Imp. Petropol. 4 : 261, 1895 ; Syd. Monogr. Ured. I : 205 ; Sacc. Syll. Fung. XVI : 303 ; Cummins, p. 454 ; Jorstad, p. 78.

Telia amphigenous, covered by the ruptured epidermis, compact, blackish brown. Teleutospores oblong-ellipsoid, narrowed at the ends, very slightly constricted at the septum, apex thickened up to 14μ, produced into a straight or curved 45μ long rostrum, smooth, yellowish brown, 35-55 x 15-25μ, pedicel hyaline, up to 80μ long.

On *Lonicera asperifolia* Hk. f. & Thoms., Barum Gol : Shokor Shal ; Satpura Nallah above Skardu, Baltistan (R. R. Stewart), III.

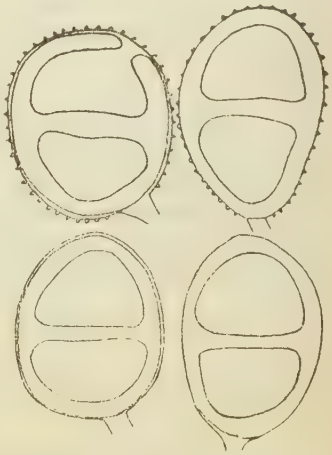


Puccinia longirostris, teleutospores.

48. **Puccinia major** (Diet.) Diet. Mitth. Thuering. Bot. Ver. N. F. p. 46, 1894. Syn.-*P. praecox* Bubak in Verh. Naturf. Ver. Brunn 36 : 123, 1898 ; Syd. Monogr. Ured. I : 67 ; Sacc. Syll. Fung. XIV : 309.

Pycnia scattered among aecia. Aecia on yellow or orange spots. Uredia amphigenous, on yellowish spots, brown, pulverulent. Uredospores globose, ellipsoid or ovoid, aculeate, chesnut brown, 22-32 x 22-28μ, germ pores 2. Telia similar but dark brown. Teleutospores broadly ellipsoid or ovoid, rounded at both ends, apex not thickened, hardly constricted at the septum, finely verruculose, deep chestnut brown, 30-35 x 24-28μ ; pedicel short, caducous.

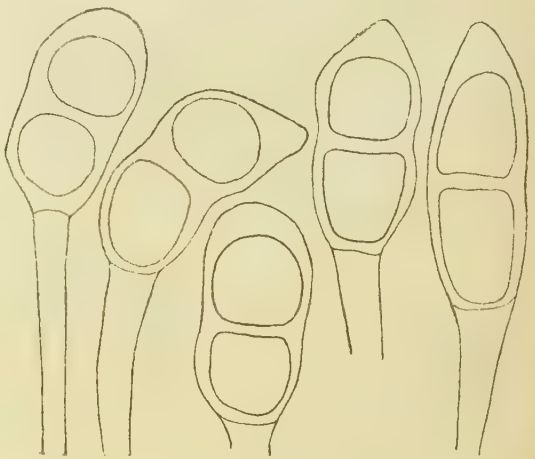
On *Dubyaea oligocephala* (Sch. Bip.) Stebbins (=*Crepis oligocephala* Sch. Bip.), Kagan Valley : Shogran, Aug. 21, 1942, I+II+III.



Puccinia major, teleutospores.

49. **Puccinia maydis** Bereng. in Atti VI, Riun. Sc. Ital. Milano p. 475, 1844 ; Syd. Monogr. Ured. I : 830 ; Sacc. Syll. Fung. VII : 659 as *P. sorghi* Schw.

Uredia amphigenous, scattered or in groups, yellowish brown. Uredospores globose, subglobose or ellipsoid, finely echinulate, pale brown, 22-30 x 20-28μ, germ pores 4. Telia similar but dark brown and long covered by epidermis. Teleutospores oblong, ellipsoid or subclavate, apex obtuse or rounded, thickened up to 8μ, slightly constricted at the septum, base rounded or attenuated, smooth, chestnut brown, 30-45 x 20-25μ, pedicel tinted, persistent, up to 45μ long.



Puccinia maydis, teleutospores.

On *Zea mays* Linn., Kagan, Aug. 24, 1949 ; Swat State, Kulali, Aug. 21, 1952, II+III ; Lahore, March 10, 1952, II ; Lyallpur.

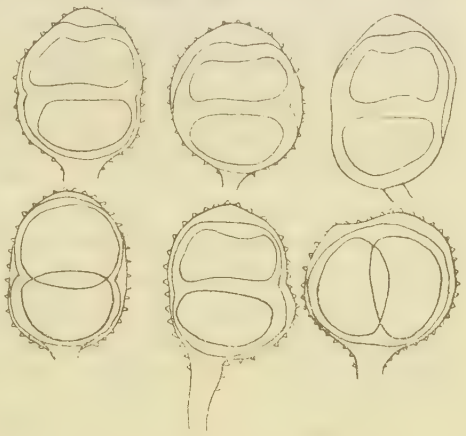
50. **Puccinia melasmioides** Tranz. ex P. & H. Syd. Monogr. Ured. I : 538 ; Sacc. Syll. Fung. XVII : 357 ; Jorstad, p. 78.

Telia hypophyllous, on yellowish spots, scattered, dark brown. Teleutospores linear-clavate, apex truncate or acute, thickened up to 6μ, not or slightly constricted at the septum, smooth, base attenuated, pale brown, 45-75 x 12-16μ, pedicel brown, persistent, up to 15μ long ; paraphyses numerous, brown.

On *Aquilegia pubiflora* Wall., Swat. State : Mt. Ilam, Aug. 12, 1952 ; Murree, Nov. 7, 1949 ; on *A. fragrans* Benth., Naltar Valley, Gilgit, leg. R. R. Stewart, July 20, 1954, III.

51. **Puccinia menthae** Pers. Syn. Meth. Fung. p. 227, 1801 ; Syd. Monogr. Ured. I : 282 ; Sacc. Syll. Fung. VII : 617 ; Arth. & Cumm., p. 403; Malik & Khan, p. 524; Sydow & Ahmad, p. 440; Butler & Bisby, p. 70.

Aecia hypophyllous, petiolicolous or caulicolous. Uredia hypophyllous on yellow or brown spots, scattered or in groups, covered by the ruptured epidermis, cinnamon. Uredospores globose to obovate, echinulate, pale brown, 17-28 x 14-20μ, germ pores 3, equatorial. Telia brown or blackish. Teleutospores subglobose to obovate, rounded at both ends, with a hyaline apical papilla, not or slightly constricted at the septum, verruculose, reddish brown, 25-30 x 22-25μ ; pedicel hyaline, up to 40μ long.



Puccinia menthae, teleutospores.

On *Mentha sylvestris* Linn., Chillianwala, May 15, 1934, II ; Hanna Valley, Quetta, Nov. 2, 1948, II+III; Mingora, Aug. 10, 1952, III ; Poonch, leg. R. R. Stewart, April 18, 1952, I ; Kagan Valley : Naran, Aug. 30, 1949, II+III ; Hasan Abdal ; Murree Hills : Gharial (R. R. Stewart) ; Peshawar (Shaw).

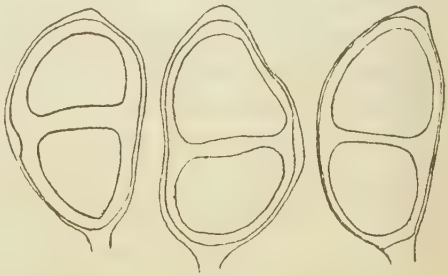
On *Origanum vulgare* Linn., Kagan Valley : Naran, Aug. 30, 1949, II ; Sharhan, July 24, 1951 ; Changla Gali, Sep. 24, 1949, II.

On *Calamintha umbrosa* Benth., Kagan Valley : Batakundi, Aug. 29, 1949, II ; Changla Gali ; on *C. clinopodium* Benth., Swat State : Kalam, Aug. 19, 1952, II ; Kagan Valley : Naran, Aug. 25, 1949, II.

On *Nepeta* sp., Kagan Valley : Saiful Maluk Sar, leg. Shaukat Ali, June 27, 1954, II.

52. **Puccinia nepalensis** Barcl. & Diet. in Hedwigia 29 : 265, 1890 ; Syd. Monogr. Ured. I : 578 ; Sacc. Syll. Fung. IX : 309 ; Malik & Khan, p. 524.

Uredia amphigenous, on spots, scattered or in groups, sometimes circinate, cinnamon, pulverulent. Uredospores globose or ovate, echinulate, yellowish brown, 26-30 x 18-22μ, germ pores 2. Telia similar, brown. Teleutospores ellipsoid, rounded at both ends, with a hyaline papilla at the apex and next to the septum, constricted at the septum, smooth, reddish brown, 25-42 x 20-24μ, pedicel hyaline, short.



Puccinia nepalensis, teleutospores.

On *Rumex nepalensis* Spreng., Kagan Valley : Shogran ; Swat State : Kalam, Aug. 23, 1952, II ; Changla Gali ; Hazara, (S. A. Malik).

It differs from *P. acetosae* in having smooth and papillate teleutospores.

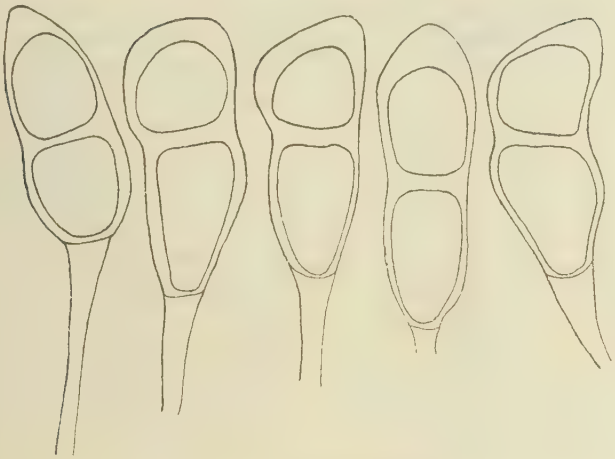
53. **Puccinia oenanthes** Diet. in Annal. Mycol. 4 : 205, 1906. Syn.- *Uredo oenanthes* Diet. in Eng. Bot. Jahrb. 28 : 290, 1900.

Uredia amphigenous, scattered, long covered by epidermis, ultimately naked, yellowish to pale brown. Uredospores globose, oval or elliptic, echinulate, 20-30 x 18-22μ, germ pores 3-4, equatorial. Telia not observed.

On *Oenanthes stolonifera* Wall., Swat State : Mingora, Aug. 10, 1952 & April 11, 1954, II.

According to Dietel (loc. cit.) the teleutospores are elliptic to oblong, rounded at the apex, not thickened, hardly constricted at the septum, pale chestnut brown, reticulate, 30-38 x 20-26μ in size.

54. **Puccinia philippinensis** Syd. in Philipp. Jour. of Sci. 8 : 266, 1913 ; Syd. Monogr. Ured. 4 : 599 ; Sacc. Syll. Fung. XXIII : 720 ; Sydow & Ahmad, p. 441.



Puccinia philippinensis, teleutospores.

Uredia hypophyllous or culmicolous, scattered or in rows, yellowish brown or brown, pulverulent. Uredospores globose or broadly elliptic, verruculose, yellowish brown, 14-19 x 14-18μ, epispore 2μ thick, with 2 equatorial germ pores. Telia black, long covered by epidermis. Teleutospores oblong to clavate, apex rounded, thickened up to 7μ, smooth, yellowish brown, 35-50 x 12-16μ.

On *Cyperus rotundus* Linn., Lahore; Sangla Hill, Nov. 6, 1951, II+III; Lyallpur; Pakpattan.

The earlier collections from this area were erroneously listed under *P. romagnoliana* by Butler & Bisby.

55. **Puccinia phlomidis** Thuem. in Bull. Soc. Imp. Natur. Moscou 23: 216, 1878; Syd. Monogr. Ured. I: 285; Jorstad, p. 79.

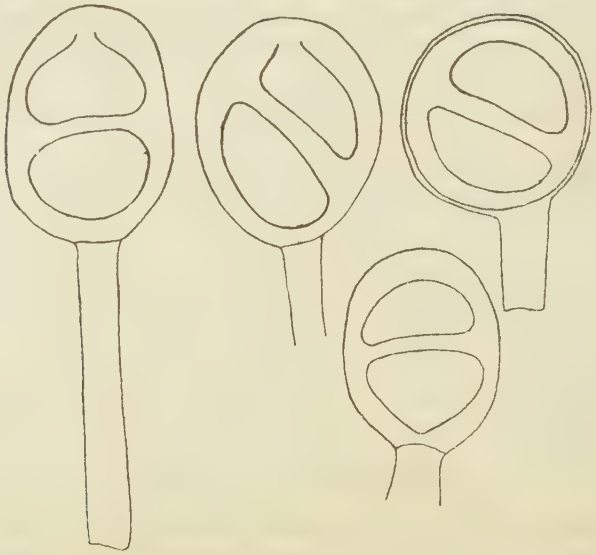
On *Lamium rhomboideum* Benth., Barum Valley: above Shokor Shal (F. Jorstad).

Aecidial stage only represented.

56. **Puccinia phyllocladiae** Cke. in Grevillea 10: 125, 1882; Syd. Monogr. Ured. I: 617; Sacc. Syll. Fung. VII: 633; Thind, Jour. Ind. Bot. Soc. 21: 195.

Uredia on branches and on phylloclades, covered by the ruptured epidermis, pale brown. Uredospores elongated or ellipsoid, 18-40x14-20μ, echinulate, yellowish brown, germ pores 2-5. Telia at first compact then pulverulent, blackish brown. Teleutospores globose, subglobose or

broadly ellipsoid, rounded at both ends, apex not or slightly thickened,



Puccinia phyllocladiae, teleutospores.

not constricted at the septum, smooth, yellowish brown, 30-35 x 26-30μ, pedicel hyaline, persistent, up to 110μ long, often obliquely placed.

On *Asparagus gracilis* Royle, Lahore, June 18, 1950, II+III ; Changa Manga, Dec. 12, 1951, II.

57. **Puccinia pimpinellae** (Str.) Mart. Prodr. Fl. Mosq., Ed. 2, p. 226, 1817 ; Syd. Monogr. Ured. I : 408 ; Sacc. Syll. Fung. VII : 616 p.p.; Arth. & Cumm., p. 403.

Uredia hypophyllous, scattered, cinnamon, pulverulent. Uredospores globose to ellipsoid, echinulate, brown, 26-32 x 22-26μ, germ pores 2. Telia similar but dark brown. Teleutospores ellipsoid, rounded at both ends, apex not thickened, hardly constricted at the septum, reticulate, brown, 28-35 x 22-25μ, pedicel hyaline, deciduous.

On *Pimpinella diversifolia* DC., Swat : Kalam, Aug. 21, 1952, II+III; Changla Gali (R. R. Stewart).

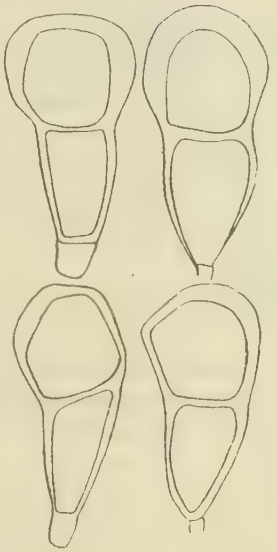
58. **Puccinia poarum** Niels. Bot. Tidsskr. III, 2 : 34, 1877. Syn.-*P. poae-alpinae* Eriks. in Ark. f. Bot. 18 : 1, 1923.

On *Poa annua* Linn., Lahore, II.

59. **Puccinia poae-nemoralis** Otth. in Mitth. Naturf. Ges. Bern 1870, p. 113, 1871. Syn.-*P. poae-sudeticae* (West.) Jorstad in Nytt Mag. Naturv. 70 : 328, 1932.

Uredia hypophyllous, scattered, pulvinate, compact. Uredospores globose, subglobose or ellipsoid, finely echinulate, 18-20μ in diam.; paraphyses numerous around and in the uredia, thick-walled, capitate, often with a narrow neck, variously curved. Telia hypophyllous, in rows, long covered by the epidermis, black. Teleutospores clavate, apex truncate, rounded or obliquely conical, thickened, slightly constricted at the septum, base attenuated, smooth, yellowish brown, 13-22 x 37-54μ, pedicel hyaline, very short.

On *Agrostis munroana*, Batakundi.

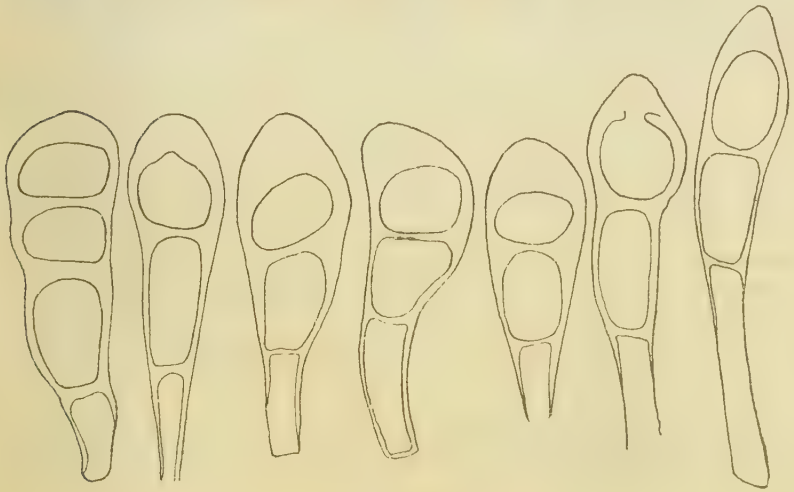


Puccinia poae-nemoralis, teleutospores.

60. **Puccinia polliniae** Barcl. in Jour. Asiatic Soc. Bengal 58 : 243, 1889 ; Syd. Monogr. Ured. I : 798 ; Sacc. Syll. Fung. IX : 313 ; Arth. & Cumm., p. 403.

On *Strobilanthes dalhousianus* Clarke, Murree Hills : Gharial, Ghora Gali ; Murree, Aug. 12, 1953, I.

61. **Puccinia polygoni-amphibii** Pers. Syn. Meth. Fung. p. 227,



Puccinia polygoni-amphibii, teleutospores.

1801 ; Syd. Monogr. Ured. I : 569 ; Sacc. Syll. Fung. XVII : 394.

Uredia hypophyllous, scattered, soon naked, pulverulent, brown. Uredospores globose, ellipsoid or ovoid, echinulate, yellowish brown, 17-30μ in diameter, germ pores 2, sub-equatorial. Telia caulicolous, dark brown. Teleutospores clavate or oblong, apex rounded, truncate or acute, thickened up to 10μ, not or very slightly constricted at the septum, base attenuated, smooth, chestnut brown, 35-50 x 15-20μ, pedicel hyaline, up to 50μ long.

On *Polygonum pterocarpum* Wall., Swat State : Kulali-Kalam, Aug. 19, 1952, II+III.

This species is distinguished from others occurring on *Polygonum* by having subequatorial germ pores in the uredospores instead of superequatorial pores. The aecidial stage of this rust occurs on *Geranium wallichianum* Sm. and *G. rectum* Trautv.

62. **Puccinia prenanthis** Kze. var. **himalensis** Barcl. in Sci. Mem. by Med. Officers of the Army of India 6 : 65, 1891 ; Syd. Monogr. Ured. I : 136 ; Sacc. Syll. Fung. XI : 189.

Uredia hypophyllous, scattered, brown, pulverulent. Uredospores globose, subglobose or ovate, finely echinulate, pale brown, 19-26 x 17-32μ. Telia similar but black. Teleutospores ellipsoid, rounded at both ends, apex not thickened, hardly constricted at the septum, minutely verruculose, brown, 26-34 x 18-24μ, pedicel hyaline, short.

On *Lactuca brunoniana* Clarke (=*Prenanthes brunoniana* DC.), Kagan Valley : Shogran, July 17, 1951, II+III ; Poonch, April 8, 1952, leg. R. R. Stewart, II ; Changla Gali.

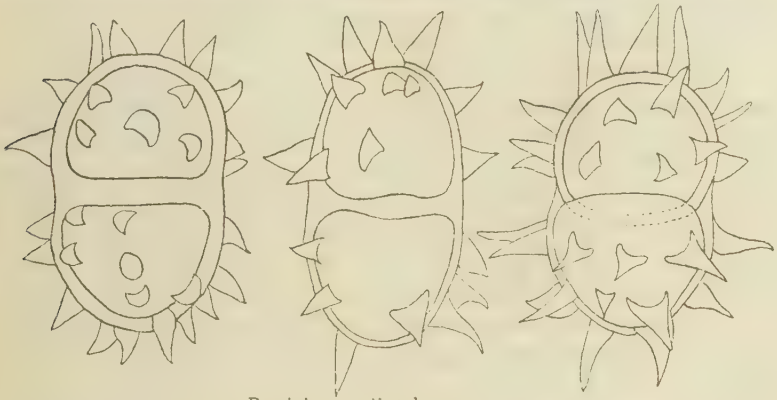
63. **Puccinia propinqua** Syd. & Butl. in Annal. Mycol. 5 : 499, 1907 ; Sacc. Syll. Fung. XXI : 692 ; Arth. & Cumm., p. 404.

Uredia hypophyllous, scattered or in rows, yellowish brown. Uredospores globose, subglobose or ovate, verruculose, pale brown, 20-24μ in diameter, epispore about 3-3.5μ thick. Telia similar but dark brown. Teleutospores ellipsoid, rounded at both ends, apex thickened up to 7μ, constricted at the septum, smooth, brown, 26-35 x 20-35μ, pedicel short ; mesospores numerous.

On *Dicanthium annulatum* (Forsk.) Stapf, Rawalpindi : Topi Park (R. R. Stewart).

64. **Puccinia prostii** Moug. in Duby, Bot. Gall. II : 891 ; Syd. Monogr. Ured. I : 638 ; Sacc. Syll. Fung. VII : 732 ; Cummins, p. 455 ; Malik & Khan, p. 524.

Telia amphigenous, without spots, scattered or confluent, long covered by epidermis, finally erumpent, dark brown. Teleutospores ovate or



Puccinia prostii, teleutospores.

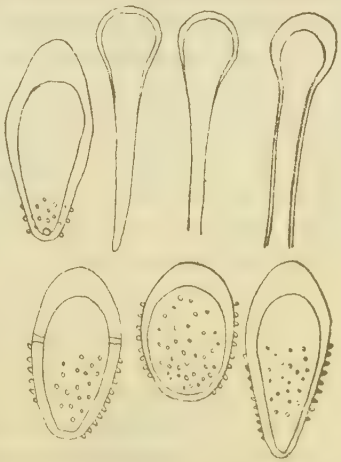
ellipsoid, rounded at both ends, hardly constricted at the septum, aculeate, spines hyaline, up to 7μ long, dark brown, 45-56 x 27-30μ, pedicel very short.

On *Tulipa stellata* Hook. f., Abbottabad, leg. A. H. Khan, April 13, 1954, III ; Margalla, Rawalpindi Distt. (R. R. Stewart.)

65. **Puccinia pruni-spinosae** Pers., Syn. Meth. Fung. p. 226, 1801 ; Syd. Monogr. Ured. I : 484 ; Sacc. Syll. Fung. VII : 648 ; Malik & Khan, p. 524.

Uredia hypophyllous, scattered, soon naked, pulverulent, cinnamon. Uredospores ellipsoid to fusiform, smooth and thickened at the apex, echinulate in the lower half, pale brown, 12-17 x 25-32μ, germ pores 4, equatorial ; paraphyses numerous, capitate. Telia not observed.

On *Prunus persica* Benth. & Hk. f., Changa Manga, Dec. 12, 1951, II ; Peshawar (S. A. Malik).

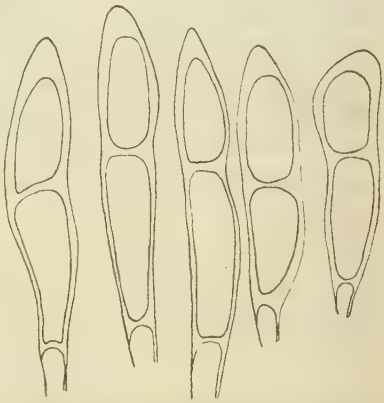


Puccinia pruni-spinosae, paraphyses & uredospores.

66. **Puccinia pulsatillae** Kalchbr. in Mathem. es termeszett. Kozlemenyek III : 307, 1865 ; Syd. Monogr. Ured. I : 536.-Syn. *P. anemone-virginiae* Schw. Schr. Naturf. Ges. Leipzig 1 : 72, 1822.

Telia hypophyllous, on brown spots, scattered, compact, dark brown. Teleutospores clavate to linear, apex rounded, truncate or acute, thickened up to 12μ, scarcely constricted at the septum, tapering downwards, smooth, yellowish or pale brown, 44-55 x 10-12μ, pedicel hyaline, persistent.

On *Anemone obtusiloba* D. Don, Changla Gali, Murree Hills, Sep. 24, 1949, III ; Nathia Gali, June 24, 1951, leg. I. I. Chaudhuri, III.



Puccinia pulsatillae, teleutospores.

67. **Puccinia pulvinata** Rabh. in Hedwigia 10 : 20, 1871 ; Syd. Monogr. Ured. I : 76 ; Sacc. Syll Fung. VII : 711 ; Butler & Bisby, p. 72.

Uredia amphigenous, without spots, scattered or confluent, brown, pulverulent. Uredospores globose, subglobose or ovate, echinulate, brown, 30-34μ in diameter, germ pores 3. Telia pulvinate, dark brown. Teleutospores ellipsoid or oblong, rounded at both ends, apex not thickened, not constricted at the septum, smooth, chestnut brown, 50-55 x 28-36μ ; pedicel hyaline, persistent, up to 150μ long ; mesospores numerous.

On *Echinops echinatus* DC., Sangla Hill ; Lahore (B. Dass).

68. **Puccinia punctiformis** (Str.) Roehl. Deutsch. Fl., Ed. 2, III, 3 : 132, 1813.- Syn. *P. obtegens* (Link) Tul. Mag. Ges. Naturf. Fr. Berlin 7 : 27, 1816.- *P. suaveolens* (Pers.) Rostr. Blomsterse Planter, p. 28, 1869. Sacc. Syll. Fung. VII : 633 ; Syd. Monogr. 1 : 55. Butler & Bisby, p. 74 ; Sydow & Ahmad, p. 440 as *P. cirsii* Lasch.

Uredia usually hypophyllous or caulicolous, covering the entire leaf surface, soon naked, pulverulent, cinnamon. Uredospores globose, subglobose or ellipsoid, echinulate, pale brown, 20-24 x 24-28μ, germ pores 3, more or less equatorial (sometimes irregularly placed). Telia similar but dark brown or blackish. Teleutospores ellipsoid or ovate-ellipsoid, apex rounded, not thickened, not or slightly constricted at the septum, base usually rounded, finely verrucose, chestnut brown, 17-25 x 25-38μ, pedicel hyaline, short.

On *Cenchrus arvensis* Hofm., Shahdara, March 25, 1949, II; Changa Manga, Feb. 18, 1950 & March 9, 1951, II–III; Lahore, leg. B. Dass, March 3, 1912, II.

69. **Puccinia purpurea** Cke. in Grevillea 5 : 15, 1876; Syd. Monogr. Ured. I : 803; Sacc. Syll. Fung. VII : 657; Butler & Bisby, p. 73.

Uredia amphigenous, on purple spots, scattered or in groups, covered by the ruptured epidermis, yellowish brown. Urediospores subglobose, ovate or pyriform, echinulate-verrucose, yellowish brown, 28-40 x 20-28μ; germ pores 4-5; paraphyses numerous, intermixed. Telia hypophyllous, long covered by epidermis, orange brown. Teleutospores ellipsoid, oblong or ovate-oblong, rounded at both ends, scarcely constricted at the septum, apex not thickened, smooth, reddish brown, 35-54 x 25-30μ, pedicel hyaline, persistent, up to 105μ long; paraphyses present.

On leaves of *Sorghum vulgare* Pers., Lahore (Cheema).

70. **Puccinia pygmaea** Erik. Fungi Paras. Scand. p. 449, 1805; Bot. Centralbl. 64 : 381, 1895; Syd. Monogr. Ured. I : 741; Sacc. Syll. Fung. XIV : 356.

Uredia hypophyllous, on yellowish spots, in rows, sometimes confluent, orange. Urediospores globose, subglobose or ellipsoid, finely echinulate, yellowish, 25-32μ in diameter or 25-32 x 22-24μ; paraphyses hyaline, clavate or capitate, thin-walled, usually straight, around or in the uredia, 50-80μ long, thickened up to 16μ at the apex. Telia hypophyllous, in rows, dark brown, long covered by epidermis. Teleutospores clavate, apex truncate, rounded or obliquely conical, slightly thickened, very slightly constricted at the septum, base attenuated, smooth, yellowish brown, 35-40 x 12-15μ, pedicel hyaline, short.

On *Agrostis munroana* Aitch. & Hemsley, Kagan Valley : Batakundi.

71. **Puccinia ranunculi-falcatae** Ahmad in Sydowia 8 : 163, 1954.

Telia amphigenous, on yellowish spots, scattered, sometimes confluent, bullate, compact, dark brown. Teleutospores very variable in form, oblong-clavate or subfusoid, apex acute or rounded, up to 10μ thick, slightly constricted at the septum, base attenuated, smooth, pale brown, 44-60 x 10-16μ, pedicel short, slightly tinted; paraphyses numerous.

On *Ranunculus falcatus* Linn., Baluchistan : Ziarat.

72. **Puccinia ribis** DC. Fl. Fr. 2 : 221, 1805; Syd. Monogr. Ured. I : 406; Sacc. Syll. Fung. VII : 679; Malik & Khan, p. 524.

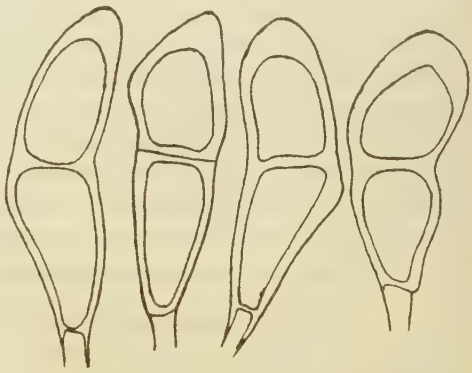
Telia epiphyllous, in yellowish or brownish orbicular spots, usually confluent, pulverulent, chestnut brown. Teleutospores ellipsoid or oblong,

rounded at both ends, very slightly constricted at the septum, verrucose, chestnut brown, 25-38 x 18μ ; pedicel as long as the spore.

On *Ribis rubrum* Linn., Swat State : Kalam ; Hazara (S. A. Malik).

73. **Puccinia romagnoliana** Maire & Sacc. in Annal. Mycol. 1 : 220, 1903 ; Syd. Monogr. Ured. I : 682 ; Sacc. Syll. Fung. XVII : 374.

Uredia hypophyllous or culmicolous, brown, pulverulent. Uredospores globose or subglobose, verruculose, brownish, 20-25 x 15-20μ, epispore 2-2.5μ thick, with 2 equatorial germ pores. Telia black, long covered by the epidermis. Teleutospores oblong-clavate or clavate, apex rounded or conical, thickened (4-11μ), slightly constricted at the septum, smooth, base attenuated, pale brown, 45-58 x 13-18μ, pedicel short, thick ; paraphyses numerous.



Puccinia romagnoliana, teleutospores.

On *Cyperus difformis* Linn., Chuharkana, Distt. Sheikhupura, April 1952, II+III.

74. **Puccinia rubigo-vera** (DC.) Wint. in Rabh. Krypt.-Fl., Ed. 2, I, 1 : 217. 1882.

On *Dactylis glomerata* Linn., Swat State : Kalam, Aug. 22, 1952 ; Kagan Valley : Batakundi, Aug. 25, 1949 ; near Kagan, Aug. 24, 1949, II.

On *Lolium perenne* Linn., Murree, August 1949.

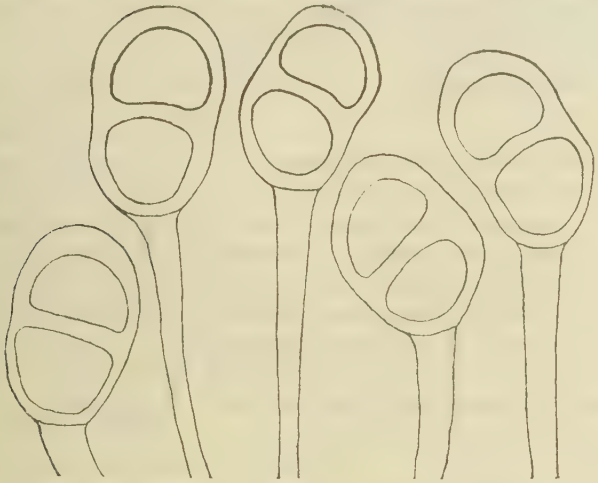
On *Aquilegia pubiflora* Wall., Kagan Valley : Sharhan, July 27, 1951; Saiful Maluk Sar, July 24, 1954, I.

According to Jorstad (Opera Botanica 1 : 68, 1953) it is a polymorphous species and embraces a number of races or race groups. Besides several others, *P. triticina* is also considered a race group and not a true species.

75. **Puccinia rufipes** Diet. in Bot. Jahrb. 1902, p. 48 ; Syd. Monogr. Ured. I : 757 ; Sacc. Syll. Fung. XVII : 377.

Uredia hypophyllous, scattered, ochraceous, pulverulent. Uredospores subglobose or ovate, ellipsoid or pyriform, echinulate, chestnut brown, 22-35 x 18-25μ, germ pores 4, equatorial ; paraphyses pallid, inter-

mixed, capitate. Telia scattered, black, amphigenous. Teleutospores



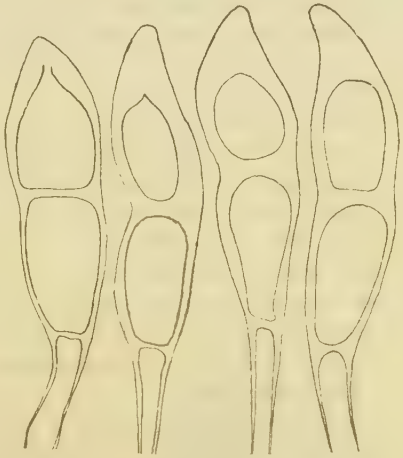
Puccinia rufipes, teleutospores.

ellipsoid, rounded at both ends, apex very slightly thickened, slightly constricted at the septum, smooth, chestnut brown, 30-38 x 20-22μ ; pedicel rufous brown, persistent, oblique or laterally inserted, up to 90μ long.

On *Imperata cylindrica* Beauv., Chillianwala, April 15, 1934, II ; Chuharkana, Nov. 13, 1949 ; Changa Manga, Feb. 18, 1950 ; Lahore, Feb. 15, 1952, II+III ; Sargodha.

76. **Puccinia saxifragae-ciliatae** Barcl. in Jour. Asiatic Soc. Bengal 58 : 234, 1889 ; Syd. Monogr. Ured. I : 506 ; Sacc. Syll. Fung. IX : 299 ; Arth. & Cumm., p. 404 ; Cummins, p. 456 ; Malik & Khan, p. 524.

Telia hypophyllous, on brown spots, scattered, compact, dark brown. Teleutospores elongate, narrowly fusoid, apex acuminate, thickened up to 14μ, constricted at the septum, base attenuated, smooth, yellowish brown, 56-70 x 10-17μ ; pedicel yellowish brown, up to 60μ long.

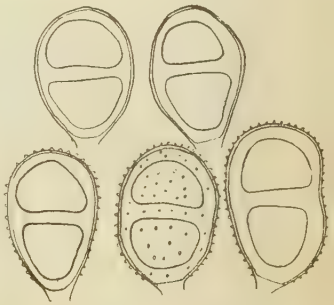


Puccinia saxifragae-ciliatae, teleutospores.

On *Saxifraga ciliata* Royle & *S. stracheyi* Hk. f. & Thoms., Kagan Valley : Shogran ; Changla Gali, Sep. 1949, III ; July 16, 1951, III ; Murree Hills; Baltistan : Thalla La (R. R. Stewart).

77. **Puccinia schirajewskii** Tranz., Mycoth. Ross. fasc. III-IV, 1911, no. 109-110 ; Sacc. Syll. Fung. XXIII : 698.

Pycnia hypophyllous or amphigenous, in yellowish spots. Uredia hypophyllous or amphigenous, cinnamon brown. Uredospores globose, subglobose or ellipsoid, 26-32μ, echinulate, yellowish brown, germ pores 3, equatorial. Telia similar, pulverulent, dark brown. Teleutospores broadly ellipsoid, attenuated at both ends, slightly constricted at the septum, 35-45 x 22-25μ, verruculose, brown, pedicel deciduous.

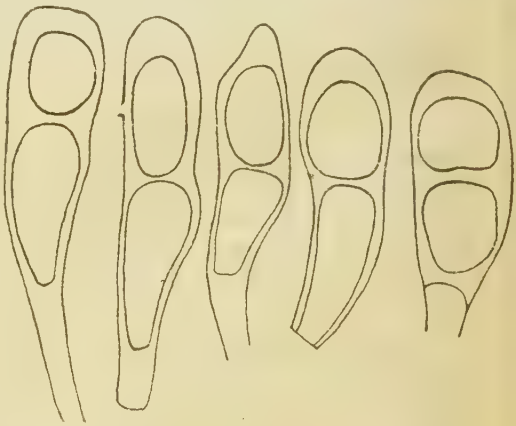


Puccinia schirajewskii, teleutospores, x 600

On *Serratula pallida* DC., Murree : Lower Topa, Sep. 22, 1949, III.

78. **Puccinia scirpi** DC., Fl. Fr. 2, p. 223, 1805 ; Syd. Monogr. Ured. I : 688 ; Sacc. Syll. Fung. VII : 659 ; Butler & Bisby, p. 74.

Uredia in rows, long covered by epidermis, finally rupturing lengthwise, ferruginous. Uredospores subglobose or ovoid, echinulate, pale brown, 19-32 x 12-24μ ; germ pores 2. Telia similar but dark brown or black. Teleutospores oblong or subclavate, apex rounded, truncate or subconical, thickened up to 9μ, hardly constricted at the septum, base attenuated, smooth, brown, 30-60 x 12-24μ, pedicel yellowish, persistent, up to 50μ long ; mesospores numerous, 24-40μ long.



Puccinia scirpi, teleutospores.

On *Scirpus littoralis* Schrad., Sangla Hill, April 12, 1951, II + III ; Chiniot, Aug. 1952, III ; Lahore (B. Dass).

79. **Puccinia silvatica** Schroet. in Cohn, Beitr. Biol. Pfl. 3 : 68, 1878 ; Syd. Monogr. Ured. I : 656 ; Sacc. Syll. Fung. VII ; 627.

On *Taraxacum officinale* Wigg., Quetta, leg. Asghar Ali, April 8, 1955, I.

"The aecidium on *Taraxacum* belongs to *P. dioicae* Magn. s. lat., or for those who prefer, to *P. silvatica*. It differs from the aecidial stages on *Taraxacum* of the autoecious species *P. variabilis* Grev. and the heteroecious *P. lasiogrostis* Tranz. ; the latter is alternating with *Stipa splendens*. In Middle Europe and eastward into Russia aecidia similar to the Quetta specimen are known to belong to rust races (usually placed with *P. silvatica* Schroet.) on *Carex arenaria, brizoides, ligerica, praecox* and *stenophylla*, but no doubt occurring on various other *Carex* species. In E. Europe a race with aecidia on *Taraxacum* alternates with *Carex capillaris*. I place *P. silvatica* as a race group under *P. dioica* s. lat. Aecidia of the present type on *Taraxacum* apparently have not as yet been recorded from Asia except from Russian parts, e.g. from Kazachsten." Jorstad.

80. **Puccinia solmsii** P. Henn. in Sacc. Syll. Fung. XIV : 357, 1899 ; Syd. Monogr. Ured. I : 568 ; Malik & Khan, p. 524.

On *Polygonum* sp., Hazara (S. A. Malik).

This species differs from the closely allied *P. polygoni-amphibii* in lacking the uredo-generation and in having smaller teleutospores (32-48 x 16-23μ) not thickened at the apex.

81. **Puccinia sonchi** Rob. ex Desm. in Ann. Sci. Nat. Bot. III, 11 : 274, 1849 ; Syd. Monogr. Ured. I : 154 ; Sacc. Syll. Fung. VII : 638 ; Malik & Khan, p. 524.

On *Sonchus arvensis* Linn., Quetta, leg. Asghar Ali, April 8, 1955, II; Upper Topa, Murree (A.H. Khan) ; Hazara (S.A. Malik).

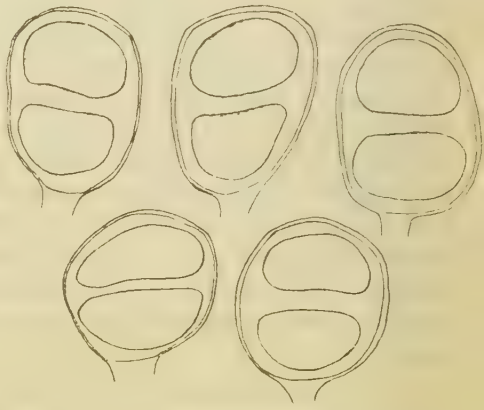
82. **Puccinia striiformis** West., Bull. Roy. Acad. Belg. 21 : 235, 1854.- Syn. *P. glumarum* (Schum.) Eriks. & Henn. in Zeitschrif. Pfl. Krankh. 4 : 197, 1894 ; Syd. Monogr. Ured. I : 706 ; Sacc. Syll. Fung. XVII : 380.- Yellow Rust.

Uredia lemon yellow, in long rows and occupying half of the leaf blade. Uredospores globose to broadly ellipsoid, echinulate, yellow, 23-35 x 20-35μ, epispore hyaline ; germ pores 6-10, scattered. Telia hypophyllous, arranged in long lines, dark brown or black, long covered by epidermis, broken up into more numerous compartments by the partitions formed by paraphyses. Teleutospores clavate, apex rounded, truncate or obliquely conical, thickened up to 8μ, slightly constricted at

the septum, base attenuated, smooth, brown, 35-65 x 12-20μ, pedicel very short or none ; paraphyses brown, numerous, curved, surrounding each little group of telia.

83. **Puccinia swertiae** (Opiz.) Wint. in Pilze Deutschl. p. 205, 1884; Syd. Monogr. Ured. I : 342 ; Sacc. Syll. Fung. VII : 613.

Uredia amphigenous, on spots, scattered or confluent, dark brown. Uredospores globose or subglobose; punctate, pale brown, 20-26μ in diameter. Telia similar. Teleutospores broadly ellipsoid, rounded at both ends, apex not thickened, smooth, chestnut brown, very slightly constricted at the septum, 28-40 x 22-29μ, pedicel hyaline, long.



Puccinia swertiae, teleutospores.

On *Swertia petiolata* Royle, Swat State : Kalam, Aug. 21, 1952, II+III ; on *S. speciosa* Wall., Kagan Valley : Shogran.

84. **Puccinia tanaceti** DC. Fl. Fr. 2 : 222, 1805 ; Syd. Monogr. Ured. 1 : 161 ; Sacc. Syll. Fung. VII : 637.-Syn. *P. pyrethri* Rabh. in Herb. myc. no. 1990 ; Syd. Monogr. Ured. 1 : 45.

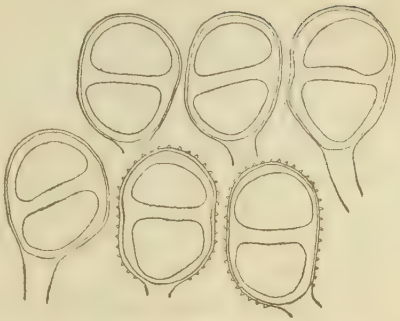
Uredia hypophyllous, on yellowish spots, scattered or in groups, pale brown, pulverulent. Uredospores subglobose, ellipsoid or ovoid, echinulate, pale yellowish brown, 22-26 x 30-42μ, germ pores 3. Telia caulicolous, confluent, soon naked, blackish. Teleutospores oblong or oblong-clavate, apex rounded, thickened (to 4μ), constricted at the septum, base attenuated, the upper cell verruculose, the lower more or less smooth, brown, 24-28 x 42-54μ ; pedicel hyaline, persistent, up to 80μ long.

On *Chrysanthemum griffithii* C. B. Clarke (=*Chr. stoliczkei* Hk. f.), Barum Valley : Shokor Shal, July 19, 1950 ; Terminal Moraine of Main Barum Glacier, leg. Wendelbo, July 20, 1950, II+III.

85. **Puccinia taraxaci** (Rebent.) Plowr. Monogr. Ured. p. 186, 1889; Syd. Monogr. Ured. 1 : 164 ; Sacc. Syll. Fung. IX : 305.

Uredia amphigenous, without spots, scattered, sometimes confluent, minute, pulverulent, brown. Uredospores globose, subglobose or

ovate, echinulate, pale brown, 16-24 x 24-27μ, germ pores 2, super-equatorial. Telia similar but dark brown. Teleutospores ellipsoid or ovate-ellipsoid, apex rounded, thickened, not or slightly constricted at the septum, base attenuated, finely verruculose, 20-26 x 25-36μ, pedicel hyaline, short.

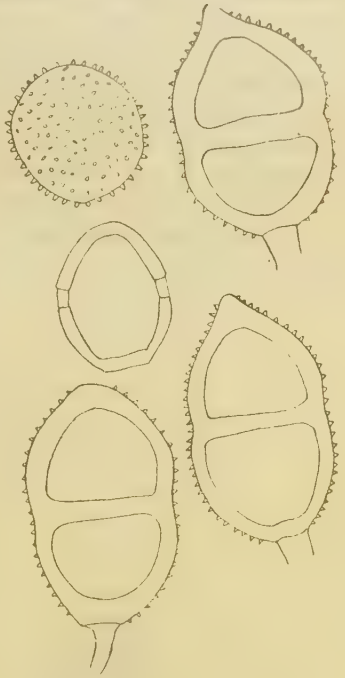


Puccinia taraxaci, teleutospores, x 600

On *Taraxacum officinale* Linn., Swat State, Kalam, Aug. 8, 1952; Kagan Valley : Batakundi, July 17, 1951, III.

86. **Puccinia tricholepidis** Sydow in Annal. Mycol. 36 : 438, 1938.

Uredia amphigenous, usually hypophyllous on pale yellowish spots, scattered or circinate around a larger one, smaller about 1.2 and the large about 1.5 mm. in diam., brown. Uredospores ovate or obovate, echinulate, 20-28 x 16-20μ, yellowish brown, germ pores 2, equatorial. Telia usually hypophyllous, 0.5-0.7 mm. in diam., dark brown. Teleutospores oblong, apex conical or rounded, thickened up to 8μ, constricted at the septum, verrucose, chestnut brown, 32-45 x 20-46μ; pedicel hyaline, slender, up to 140μ long.



Puccinia tricholepidis, uredo- & teleutospores.

On *Tricholepis stewartii* C. B. Clarke, Murree Hills : Dunga Gali, Aug. 15, 1954, II+III; Changla Gali, Sept. 24, 1949, II.

"H. Sydow has described *P. tricholepidis* on *Tricholepis elongata* from Sarahan, Bashar. He described the teleutospores only, but the rust is no doubt a brachy-form. The present rust is probably the same; it possesses 2 equatorial germ pores in the uredospores and resembles considerably *P.*

hypochoeridis Oud. (=*P. hieracii* Mart. var. *hypochoeridis* (Oud.) Jorst.)" Jorstad.

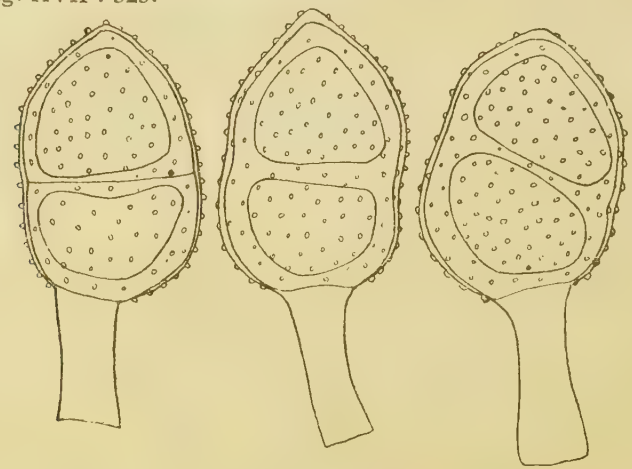
87. **Puccinia triticina** Erikss. in Ann. Sci. Nat. Ser. VIII, 9 : 270, 11899. Syd. Monogr. Ured. I : 716 ; Sacc. Syll. Fung. XVII : 376.-Syn. *P. rubigo-vera* f. sp. *tritici* (Eriks.) Carlet.U.S. Dept. of Agric., Biv. Veget. Phys. a. Pathol. Bull. 16 : 19, 1899.

Uredia amphigenous, usually epiphyllous, scattered, oblong, medium ferruginous. Uredospores globose or subglobose, echinulate, yellowish, 22-26 in diam. Telia hypophyllous or culmicolous, scattered, on culms usually arranged in rows, oblong, covered by epidermis, black. Teleutospores oblong-clavate, apex rounded, sometimes obtuse, obliquely pointed, slightly thickened, slightly constricted at the septum, base attenuated, smooth, brown, 14-20 x 32-42μ ; pedicel short ; paraphyses brown, numerous.

Puccinia triticina, teleutospores.

On *Triticum aestivum* Linn., common throughout the area.

88. **Puccinia turgida** P. & H. Syd. Monogr. Ured. I : 266 ; Sacc. Syll. Fung. XVII . 323.



Pucciniaturgida, teleutospores.

Uredia amphigenous, without spots, scattered, covered by the ruptured epidermis, pulverulent, brown. Uredospores ovate or ellipsoid, aculeate, yellowish, 35-40 x 15-28μ. Telia similar but dark brown. Teleutospores ellipsoid or oval, apex rounded, rarely conical, not thickened, barely constricted at the septum, base rounded, densely verrucose, opaque, dark brown, 30-50 x 30-34μ, epispore 5-8μ thick ; pedicel hyaline, thick, much inflated at the base, up to 56μ long, sometimes obliquely inserted.

On leaves of *Lycium europeum* Linn., Lahore, Feb. 17, 1939, II+III.

89. **Puccinia tuyutensis** Speg. Fungi Argent. 4 : 25, 1881.- Syn. *P. cressae* (DC.) Lagerh. in Bol. Soc. Brot. p. 131, 1889 ; Syd. Monogr. Ured. I : 320 ; Sacc. Syll. Fung. IX : 307.

On *Cressa cretica* Linn., Karachi (M.S. Jaffrey), I.

Lindquist (Bolet. Soc. Argent. Bot. 5, p. 35, 1953) has shown that the valid name of this rust is *P. tuyutensis*.

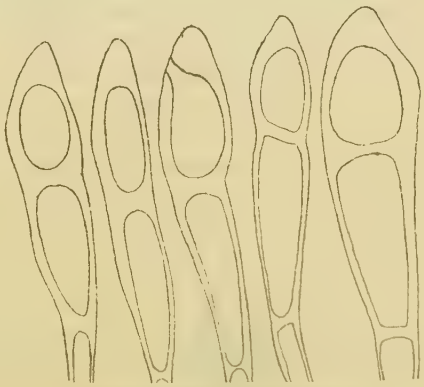
90. **Puccinia umbilici** Guep. ex Duby, Bot. Gall. p. 890, 1830 ; Syd. Monogr. Ured. I : 492 ; Sacc. Syll. Fung. VII : 700 ; Jorstad, p. 81.

Telia amphigenous or caulicolous, circinate or confluent, pulverulent, blackish brown. Teleutospores broadly ellipsoid, rounded at both ends, apex not thickened, often with a minute, hyaline papilla, not or barely constricted at the septum, smooth, brown, 25-32 x 18-26μ, pedicel short, hyaline.

On *Sedum heterodontum* Hook. f. & Thoms., Barum Gol, Shokor Shal (Wendelbo).

91. **Puccinia urticae** Barcl. in Sci. Mem. by Med. Officers of the Army of India II : 38, 1887 : Syd. Monogr. Ured. I; 590 ; Sacc. Syll. Fung. IX : 299.

Telia hypophyllous, on large yellow spots, scattered or in groups, compact, ferruginous. Teleutospores clavate or oblong-clavate, apex conical sometimes acute, thickened to about 8μ, slightly constricted at the septum, base attenuated, smooth,



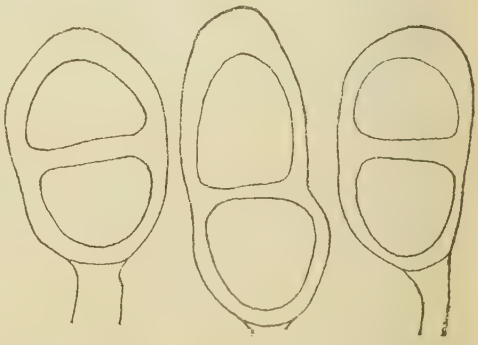
Puccinia urticae, teleutospores.

yellowish brown, 42-60 x 10-19μ ; pedicel hyaline, persistent, as long as the spore.

On *Urtica dioica*, Kagan Valley, August 1950, III.

92. **Puccinia versicolor** Diet. & Holw. in Bot. Gaz. 27 : 28, 1897 ; Syd. Monogr. Ured. I : 724 ; Sacc. Syll. Fung. XIV : 352.

Uredia hypophyllous, on purple spots, scattered, yellow, pulverulent. Uredospores globose, subglobose or ovate, finely echinulate, subhyaline, 28-38 x 25-32μ, epispore very thick. Telia compact, black, 1-4 mm. long. Teleutospores ellipsoid or oblong-ellipsoid, apex rounded, thickened to 8.5μ, not or slightly constricted at the septum, base rounded, smooth, brown, 40-50 x 22-25μ ; pedicel hyaline, persistent, up to 120μ long.



Puccinia versicolor, teleutospores.

On *Heteropogon contortus* (Linn.) Beauv., Choa Saidan Shah, March 13, 1950, III.

93. **Puccinia violae** (Schum.) DC. Fl. Fr. 5 : p. 62, 1815 ; Syd. Monogr. Ured. I : 439 ; Syll. Fung. VII : 609 ; Malik & Khan, p. 524.

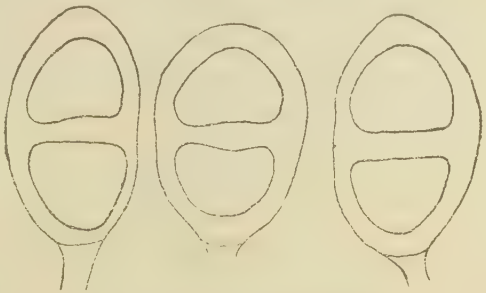
Uredia hypophyllous, scattered or circinate, soon naked, pulverulent, cinnamon brown. Uredospores globose or ellipsoid, echinulate, brownish, 20-26 x 17-22μ, germ pores 2. Telia similar but dark brown. Teleutospores ellipsoid to oblong, rounded at both ends or sometimes attenuated downwards, apex thickened and pale in colour, barely constricted at the septum, punctate, chestnut brown, 22-30 x 15-20 μ ; pedicel hyaline, deciduous.

Puccinia violae, teleutospores.

On *Viola canescens* Wall., Swat State : Kalam, Aug. 23, 1952, II+ III ; on *V. serpens* Wall., (S.A. Malik) ; on *Viola caespitosa* D. Don (=*V. Patrinii* Hk. f.), Kagan Valley : Shogran, August 1951, III.

94. **Puccinia wattiana** Barcl. in Jour. Asiatic Soc. Bengal 59 : 109, 1890 ; Syd. Monogr. Ured. I : 544 ; Sacc. Syll. Fung. IX : 298.

Telia hypophyllous, on spots, circinate, compact, dark brown. Teleutospores oblong, apex rounded, thickened to 6μ, slightly constricted at the septum, base rounded or attenuated, smooth, brown, 40 x 20; pedicel hyaline, delicate, up to 60μ long.



Puccinia wattiana, teleutospores.

On *Clematis grata* Wall., Swat State : Miana, Aug. 11, 1952, III ; Murree, August 1948, III.

Pucciniastrum Otth.

Pycnia subcuticular. Aecia erumpent, cylindric, rimosely dehiscent. Uredia subepidermal, minute, covered with a pseudoperidium, opening by an apical pore. Uredospores solitary, epispore hyaline, without germ pores. Telia subepidermal, intercellular, sometimes forming minute crusts. Teleutospores spherical to oblong, vertically or obliquely 2 to many septate, smooth, colourless.

1. **Pucciniastrum areolatum** (Fr.) Otth. in Wartm. & Schrenk. Krypt., p. 521, 1863.- Syn. *Thekopsora areolata* (Fr.) Magn., Sitzungsber. der Ges. Natur. Freunde zu Berlin, p. 58, 1875.- *Th. padi* Groves, British Rust Fungi, p. 368, 1913.

On cone scales of *Picea morinda* Link, Kagan Valley : Shogran ; Murree Hills, Changla Gali, I. Very common.

The rust has been described as regularly host-alternating between *Prunus padus* and *Picea* but the telial stage has not been observed in this country. According to Jorstad it causes considerable injury to young terminal spruce shoots.

2. **Pucciniastrum agrimoniae** (Diet.) Tranzsch. in Scripta Bot. Hort. Univ. Petropol. 4 : 301, 1895 ; Syd. Monogr. Ured. I : 446 ; Malik & Khan, p. 524.

On *Agrimonia eupatorium* Linn., Hazara (S. A. Malik).

Pucciniostele Tranzsch. & Kom.

Pycnia epiphyllous, subcuticular. Aecia of the *Caeoma*- type, without a pseudoperidium and paraphyses. Uredospores absent. Telia of

two kinds, primary irregular, subgelatinous, at last more or less pulverulent, and secondary minute, long covered by epidermis, at first waxy then pulverulent. Primary teleutospores 1-septate, smooth. Secondary teleutospores in long chains, easily separable, 1-celled, smooth.

1. **Pucciniostele clarkiana** (Barcl.) Diet. in Engler's Bot. Jahrb. 27 : 564, 1899 ; Arthur & Cummins in Mycologia 25 : 406, 1933 ; Arth. & Cumm., p. 406.

On *Astilbe rivularis* Ham., Kagan Valley : Sharhan, July 26, 1951 ; Changla Gali, Murree Hills (R.R. Stewart).

Ravenelia Berk.

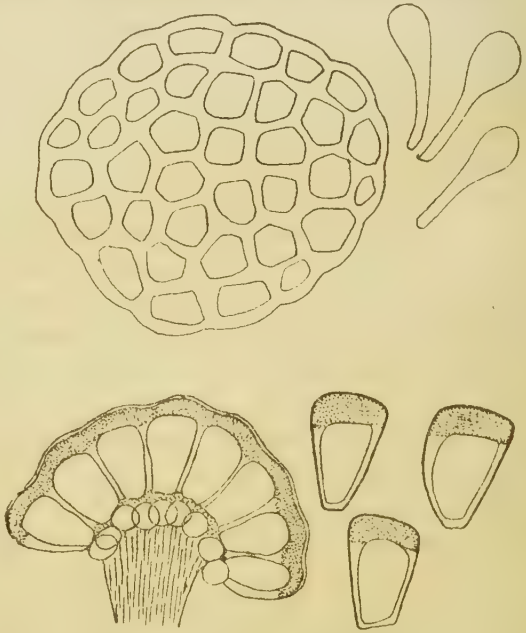
Pycnia subcuticular. Aecia, when present, with a pseudoperidium. Uredia generally minute, subcuticular or subepidermal, often paraphysate, but without a pseudoperidium. Uredospores solitary on pedicels, with numerous germ pores. Telia generally minute, subcuticular or subepidermal. Teleutospores united laterally to form a hemispheric head of one layer of fertile spores subtended by colourless cysts ; pedicel compound.

1. **Ravenelia mimosae-himalayae** sp. nov.

Soris uredosporiferis amphigenis, dispersis vel aggregatis, saepe circinatim dispositis, subflavis, minutis. Uredosporis globosis vel ellipsoideis, echinulatis, 16-20μ diam. vel 10 x 20μ ; episporis 2μ crassis, poris germ, 8 (-10) ; paraphyses numerosis, clavatis, 40μ longis, apice crassiusculis (-12μ). Soris teleutosporis amphigenis, dispersis vel aggregatis, epidermide erumpente tectis, brunneis. Capitulis teleutosporarum convexis, orbicularis vel subhemisphaericis, 60-100μ diam., brunneis, ex sporis 6-8 in omni directione compositis, marginaliter levis ; sporis singulis 18-24 x 18-22μ, epispori apice crassiore (-10μ). Cystidiis oblongis, eodem numero quo sporis singulis, in aqua diffuentibus ; pedicello hyalino, brevi, deciduo, crasso.

Hab. in foliis *Mimosae hymalayae*, Lahore: Changa Manga, 10. 1. 54; no. 10054. Typus depositus in Herb. C.M.I

Uredia amphigenous, scattered or gregarious ; often circinate, pale yellowish, minute, 150-500μ



Ravenelia mimosae-himalayae, telial head, teleutospores and paraphyses.

in diam. Uredospores globose or oval, echinulate, 16-20μ in diam.; epispore 2μ thick with 8 (-10) germ pores; paraphyses numerous, clavate, up to 40μ long, swollen at the apex to 12μ. Telia amphigenous, scattered or gregarious, covered by ruptured epidermis, up to 500μ in diameter, chestnut brown. Telial head convex, orbicular or subhemispheric, 60-100μ in diam., chestnut brown, 6-8 spores in a cross section, margin smooth; single spore 18-34 x 18-22μ, epispore thickened to 10μ at the apex; cysts oblong, as many as the spores, swelling and easily diffusing in water; pedicel short, thick, hyaline, deciduous.

On *Mimosa himalayana* Gamble (=*M. rubicaulis* Hk. f.), Lahore: Changa Manga, 10. 1. 54, no. 10054, type.

2. **Ravenelia sessilis** Berk. in Jour. Linn. Soc. Bot. 14 : 93, 1875; Syd. Monogr. Ured. 3 : 248; Sacc. Syll. Fung. VII : 772.

Uredia subcuticular, hypophyllous or on pods, pale brown. Uredospores ellipsoid or ovate, echinulate, yellowish brown, 15-22 x 24-32μ; epispore 1.5μ thick, the apex thickened to about 3.5μ, germ pores 4, equatorial; paraphyses absent. Telia amphigenous, usually hypophyllous and on pods, scattered or sometimes in circinate groups, up to 5mm. long, dark brown or blackish, covered by the ruptured cuticle. Telial head convex, orbicular, 80-115μ in diameter, chesnut brown, 5-7 spores in a cross section, margin only with few scattered warts, single spore 15-20 x 28μ, epispore thickened to 6μ at the apex; cysts crowded, hyaline, ovate, as many as the individual spores, swelling and diffusing in water; pedicel compound, very short.

On leaves and pods of *Albizzia lebbek* (Linn.) Benth., Sialkot, Sep. 20, 1952; Changa Manga, Jan. 10, 1954; II+III.

3. **Ravenelia taslimii** Mundkur in Mycologia 30 : 687, 1938; Sydow & Ahmad in Annal. Mycol. 37 : 441, 1939.

Uredia subcuticular, hypophyllous, minute, yellowish brown. Uredospores oval or oblong, finely and shortly aculeate-verrucose, 13-15 x 17-26μ, epispore uniformly thickened, pale brown, germ pores 4, equatorial. Telia amphigenous or caulicolous, black, in groups or confluent, 0.1-1mm. in diam., subepidermal; paraphyses absent. Telial heads convex, hemispheric to orbicular, smooth, chestnut brown, 85-128μ in diameter, formed of 10-12 spores in a cross section, smooth, single spore 8-11 x 10-12μ, epispore thickened to 5μ at the apex; cysts hyaline, oblong-ovate, as many as the individual spores, swelling and diffusing in water; pedicel short, thick, hyaline, deciduous.

On *Acacia modesta* Wall., Lahore, Jan. 8, 1950; Changa Manga, Nov. 24, 1934; Taxilla, Oct. 1, 1949; Rawalpindi; Choa Saidan Shah, March 13, 1950; II+III.

Trachyspora Fckl.

Pycnia and aecia absent ; uredospores solitary on pedicels ; epispore hyaline without germ pores. Teleutospores 1-celled ; epispore intensely brown, with large irregular warts and without a germ pore ; pedicel short, deciduous.

1. **Trachyspora alchemillae** (Pers.) Fckl. in Bot. Zeit. 19 : 250, 1861.- Syn. *Uromyces alchemillae* (Pers.) Lev. in Ann. Sci. nat. Ser. III, 8 : 371, 1847 ; Syd. Monogr. Ured. 2 : 196 ; Sacc. Syll. Fung. VII : 553.

On *Alchemilla vulgaris* Linn., Skardu, Baltistan (R.R. Stewart).

Uromyces Link

Pycnia, when present, usually epiphyllous, subepidermal. Aecia with a well developed pseudoperidium. Uredia, when present, minute, sometimes accompanied by paraphyses. Uredospores solitary on long stalks, with 2 to several germ pores. Teleutospores 1-celled, with a single apical germ pore, smooth, striate or echinulate, brown, stalked.

1. **Uromyces apludae** Syd. & Butl. in Annal. Mycol. 5 : 493, 1907 ; Syd. Monogr. Ured. 2 : 321 ; Sacc. Syll. Fung. XXI : 591.

On *Apluda mutica* Linn., Lahore. 11.

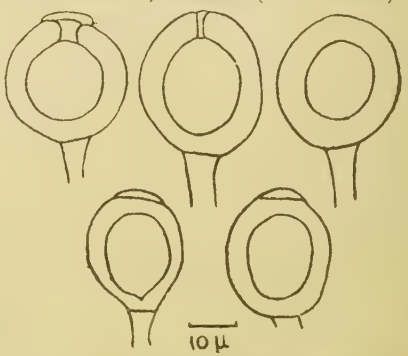
2. **Uromyces appendiculatus** (Pers.) Link in Obs. Myc. II, p. 28, 1816 ; Syd. Monogr. Ured. 2 : 120 ; Sacc. Syll. Fung. VII : 535.

Uredia hypophyllous, scattered or aggregated, minute, soon naked, covered by the ruptured epidermis, orange yellow. Uredospores globose, subglobose or ovate, echinulate, pale brown, 18-26μ in diam., epispore about 1.5μ thick, germ pores 2. Telia similar but dark brown. Teleutospores subglobose or ellipsoid, apex rounded with a large hyaline papilla, chestnut brown, 20-30 x 25-38μ, epispore 3.5μ thick, pedicel hyaline, as long as the spore.

On *Dolichos lablab* Linn., Swat State : Kulali ; Hazara (S.A. Malik).

3. **Uromyces andropogonis-annulati** Syd. & Butler in Annal. Mycol. 5 : 492, 1907 ; Syd. Monogr. Ured. II : 320 ; Sacc. Syll. Fung. XXI: 592; Sydow & Ahmad, p. 440 ; Arth. & Cumm., p. 406.

Uredia hypophyllous, in rows, ferruginous. Uredospores globose, subglobose or ovate, echinulate, yellowish brown, 16-24 x 20-24μ. Telia similar but dark brown. Teleutospores globose or subglo-



Uromyces andropogonis-annulati. teleutospores.

bose, apex not thickened, rounded, papillate, papilla broad, hyaline, 4μ thick, smooth, chestnut brown, 18-26 x 22-28μ; epispore 4-6μ thick; pedicel hyaline, short.

On *Dicanthium annulatum* Stapf, Chillianwala, May 1, 1935; Sangla Hill, Oct. 28, 1917; Rawalpindi, Nov. 7, 1951; Swat State: Kulali-Kalam, Aug. 19, 1952; Khangah Dogran, Gujranwala District (R.R. Stewart).

4. **Uromyces anthyllidis** (Grev.) Schroet. in Hedwigia 14: 162, 1875; Syd. Monogr. Ured. 2: 64; Sacc. Syll. Fung. VII: 551.

Uredia amphigenous, scattered, pulverulent, cinnamon. Uredospores globose or subglobose, sparsely echinulate, yellowish brown, 20-24μ in diameter, epispore 3-4μ thick, with 4-8 germ pores. Telia similar but darker in colour. Teleutospores globose, subglobose or ovate, apex papillate, verrucose, brown, 16-20 x 18-22μ; pedicel hyaline, short.

On *Trigonella gracilis* Benth., Upper Topa, Murree, Sep. 21, 1951; *T. incisa* Benth. (=*T. polycerata* auctt.) Sangla Hill, April 22, 1952; Gakkhar, April 1949; Chillianwala, April 13, 1934.

5. **Uromyces capitatus** Syd. in Oester. Bot. Zeitschr. 52: 182, 1902; Syd. Monogr. Ured. 2: 93; Sacc. Syll. Fung. XVIII: 250.

Uredospores globose, subglobose or ellipsoid, minutely echinulate, light brown, 16-22μ in diam., epispore 1.5μ thick. Teleutospores globose or depressed globose, apex not thickened, densely verrucose, 16-24μ in diam., dark brown to almost opaque; pedicel hyaline, persistent, as long as the spores.

On *Desmodium tiliaefolium* G. Don, Kagan Valley: Sharhan, July 23, 1951; Swat State: Madian, Aug. 15, 1952.

6. **Uromyces chenopodii** Schroet. in Kunze, Fung. Sel., no. 214; Monogr. Ured. 2: 233; Sacc. Syll. Fung. VII: 548; Butler & Bisby, p. 81.

Uredia scattered or in groups, covered by the ruptured epidermis, cinnamon. Uredospores globose, oval or oblong, echinulate, yellowish brown, 20-25 x 16-20μ, epispore 1.5μ thick. [Telia larger, compact, dark brown. Teleutospores oval or subpyriform, rounded or conical at the apex, not or slightly thickened, smooth, brown, 18-20 x 28-34μ; pedicel pale brown, persistent, up to 80 μ long.]

On *Suaeda fruticosa* Forsk. Lahore; Sangla Hill, May 1, 1950 & April 12, 1951, II.

7. **Uromyces ciceris-arietini** (Grog.) Jacky. & Boy. in Ann. de l'Ecole Nat. Agric. dem Montpellier, p. 19, 1894; Syd. Monogr. Ured. 2:

84 ; Sacc. Syll. Fung. XI : 175.

Uredia hypophyllous, scattered, pulverulent, cinnamon. Uredospores globose or subglobose, echinulate, yellowish brown, 24-28μ in diam., epispore 3-4μ thick, germ pores 4-8. [Telia similar but dark brown. Teleutospores globose, subglobose or ovate, apex rounded, not thickened, verrucose, brown, 18-22 x 20-26μ ; pedicel short, hyaline].

On *Cicer arietinum* Linn., Chillianwala, April 13, 1934 ; Sangla Hill, April 15, 1952, II.

8. **Uromyces decoratus** Syd. in Annal. Mycol. 5 : 491, 1907 ; Monogr. Ured. 2 : 88; Sacc. Syll. Fung. XXI : 549 ; Butler & Bisby, p. 81.

Uredia hypophyllous, scattered or in groups, pulverulent, light brown. Uredospores globose, subglobose or ellipsoid, echinulate, light brown, 20-24μ in diam., epispore 1.5μ thick. [Telia similar but blackish. Teleutospores subglobose, ovate or oblong, apex not thickened, papillate, base rounded or attenuated, verrucose, chestnut brown, 16-20 x 20-30μ ; epispore 1.5-2μ thick ; pedicel hyaline, deciduous].

On *Crotolaria juncea* Linn., Sialkot, Oct. 10, 1952, II.

9. **Uromyces eragrostidis** Tracy in Jour. Myc. p. 281, 1893 ; Syd. Monogr. Ured. 2 : 326 ; Syll. Fung. XI : 182 ; Butler & Bisby, p. 82.

Uredia amphigenous, scattered, pulverulent, soon naked, brown. Uredospores globose, subglobose or ellipsoid, finely echinulate, yellow, 18-22 x 20-24μ, epispore 1.5μ thick. Telia similar but dark brown. Teleutospores ovate, oblong or clavate, apex rounded or truncate, to 5μ thick, base attenuated, smooth, light brown, 16-20 x 24-30μ ; pedicel yellowish, up to 30μ long.

On leaves of *Desmostachya bipinnata* Stapf, Lahore, Feb. 4, 1952 ; Sialkot ; Chenab Bank, Punjab (Cheema).

10. **Uromyces fabae** (Pers.) de Bary in Ann. Sci. Nat. Bot. IV, 20 : 80, 1863 ; Syd. Monogr. Ured. 2 : 103 ; Sacc. Syll. Fung. VII : 531 p. p. ; Sydow & Ahmad, p. 439; Malik & Khan, p. 524.

Aecia hypophyllous, scattered or in groups. Uredia amphigenous, scattered, pulverulent, pale brown. Uredospores globose, ellipsoid or ovate, echinulate, pale brown, 20-24 x 22-30μ, epispore 1.5-2.5μ thick, germ pores 3-4. Telia similar but blackish brown. Teleutospores subglobose, ovate or ellipsoid, apex thickened (6-8μ), rounded or truncate, sometimes papillate, smooth, brown, 20-25 x 30-36μ ; pedicel yellowish, persistent, up to 80μ long.

On *Pisum sativum* Linn. and *Vicia sativa* Linn., Chillianwala, April 16, 1934 ; Peshawar ; on *Lathyrus odoratus* Linn., Peshawar (S. A. Malik) ;

on *Vicia faba* Linn., Lyallpur (Mitter).

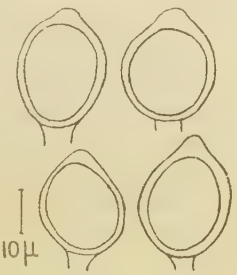
11. **Uromyces fritillariae** (Schl.) Thuem., Oesterr. Bot. Zeitschr. 297, 1876.

On *Fritillaria roylei*, Kagan Valley : Saiful Maluk Sar, July 12, 1952 (Shaukat Ali).

The identification of this rust is purely tentative as no teleutospores are present in the present collection. It can equally well be placed under *U. mogianensis* Bub., reported from Turkestan and Morocco. In the present collection the accidiospores are usually ellipsoid or oblong and the epispore 2-3.5μ thick as compared with those of *U. mogianensis*, in which the spores are usually globose and the epispore 3-6μ thick.

12. **Uromyces geranii** (DC.) Lev. in Ann. Sci. Nat. Bot. III, 8 : 371 & 376 ; Syd. Monogr Ured. 2 : 190.

Uredia hypophyllous, on yellowish spots, scattered, covered by the ruptured epidermis, pulverulent, cinnamon. Uredospores globose, subglobose or ellipsoid, sparsely echinulate, brown, 18-24 x 20-30μ, epispore 2μ thick, germ pores 1-2. Telia similar but dark brown. Teleutospores globose or ellipsoid, apex papillate, papilla up to 6μ long, smooth, brown, 20-34 x 24-34μ, pedicel hyaline, short.



Uromyces geranii, teleutospores.

On *Geranium aconitifolius* L'Har., Kagan Valley : Shogran ; Swat State : Kalam, Aug. 21, 1952, II+III.

13. **Uromyces heteromallus** Syd. apud Sydow & Ahmad in Annal. Mycol. 37 : 439, 1939.

Uredia medium or large, producing large galls on the stem, scattered or aggregated, covered by the ruptured epidermis, dark brown, pulverulent. Uredospores ellipsoid or oblong, elongated, pyriform, rarely oval, light brown, upper half with numerous warts, the lower with scattered warts and the base almost smooth, 16-21 x 27-36μ, germ pores 6, equatorial, in two opposite rows. Telia not known.

On *Haloxylon recurvum* Bunge, Lyallpur : Darkhana.

14. **Uromyces ignobilis** (Syd.) Arth. in Mycologia 7 : 181, 1915.- Syn. *Uredo ignobilis* Syd. in Annal. Mycol. 4 : 444, 1906.-*Uromyces major* Arth. in Bull. Torr. Bot. Club 38 : 377, 1911.

Uredia hypophyllous, scattered or aggregated, minute, soon naked, pulverulent, ochraceous brown. Uredospores globose, subglobose, or

ovate, echinulate, yellowish brown, 17-25 x 18-27μ, epispore 1.5-2μ thick, with 4 equatorial germ pores. Telia black, long covered by the epidermis. Teleutospores ovate or ellipsoid, 16-19 x 22-28μ, apically 2-3μ thick; pedicel 18μ long.

On *Sporobolus pallidus* Boiss., Lahore, Nov. 9, 1955, leg. Akhlaq Ahmad.

15. **Uromyces kondoi** R. Miura; Cummins in Mycologia 35: 457. 1943.

Cummins (l.c.) points out that since there are only uredia present in the collection from Rawalpindi and since only telia were described by Miura the determination is purely tentative.

On *Guldenstaedtia* sp., Rawalpindi (R.R. Stewart).

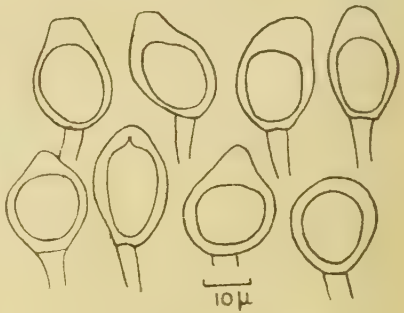
16. **Uromyces lapponicus** Lagerh. in Bot. Notiz. 7: 274, 1890; Syd. Monogr. Ured. 2: 69 under *U. carneus*; Sacc. Syll. Fung. IX: 292.

On species of *Astragalus* and *Oxytropis*, Baltistan.

According to Jorstad it is quite close to *U. phacae-frigidae*, at least in the teleutospores. In this species the telia develop from a localized mycelium whereas in *U. phacae-frigidae* they develop from a systemic mycelium. The reverse is true for the aecial stage which develops from the systemic mycelium in *U. lapponicus* and from lacalized mycelium in *U. phacae-frigidae*.

17. **Uromyces lespedezae-sericeae** sp. nov.

Uredia hypophyllous, on yellowish spots, covered by the ruptured epidermis, pulverulent, cinnamon. Uredospores globose or subglobose, echinulate, yellowish brown, 17-24 x 22-28μ; germ pores 4, scattered, covered by prominent hyaline caps. Telia black, pulverulent. Teleutospores ellipsoid or oblong, smooth, brown, 14-18 x 22-26μ, apex rounded or conical, 6-10μ thick, base rounded; pedicel hyaline, up to 26μ long.



Uromyces lespedezae-sericeae, teleutospores.

On *Lespedeza sericea* (Thunb.) Miq., Abbottabad; Upper Topa, Murree (A.H. Khan); Ghora Gali (Asghar Ali).

Soris uredosporiferous hypophyllis, in maculis subflavis, epidermide erumpente tectis, pulverulentis, colore cinnamoni; paraphyses numeris, hyalinis, curvatis. Uredo-

sporis globosis vel subglobosis, echinulatis, flavis 17-24 x 22-28μ, pori germ. 4, dispersis, capulis tectis. Soris teleutosporiferis pulverulentis, nigris. Teloutosporis vel oblongis, levis, brunneis, 14-18 x 22-26μ, apice rotundate vel conicis, 6-10μ crassis, basi rotundate ; pedicello, hyalino, 22-26μ longo.

Hab. in foliis *Lespedezae sericeae*, Murree, 18. 9. 51, no. 11014. Typus depositus in Herb. C. M. I.

18. **Uromyces lineolatus** (Desm.) Schroet. in Rabh. Fungi eur. no. 2077, 1875.- Syn. *U. scirpi* (Cast.) Burr. in Bot. Gaz. 9 : 188, 1884 ; Syd. Monogr. Ured. 2 : 302 ; Sacc. Syll. Fung. VII : 558.

Uredia hypophyllous, scattered or in rows, pulverulent, cinnamon. Uredospores globose, ovate or ellipsoid, echinulate, yellowish brown, 18-24 x 24-34μ, epispore 1.5-2μ thick, germ pores 3, equatorial. [Telia amphigenous, dark brown. Teleutospores ovate, oblong or clavate, apex thickened (up to 12μ), attenuated, base attenuated, smooth, light brown, 18-24 x 30-42μ ; pedicel brownish, up to 50μ long.]

On *Scirpus maritimus* Linn., Lahore, April 15, 1953 ; Sheikhupura, April 12, 1951, II.

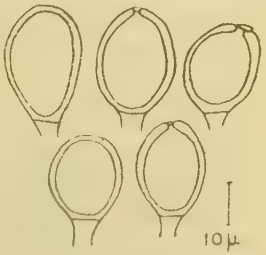
19. **Uromyces lycoctoni** (Kalchbr.) Trotter, Fl. Ital. Crypt. I : 64, 1908. *U. aconiti-lycoctoni* (DC.) Winter in Hedwigia 19 : 35, 1880.- *U. aconiti* Fuck. in Jahrb. Nass. Ver. Nat. 23-24 : 61, 1869.

Aecidia on leaves or petioles. Uredospores globose, subglobose, or ellipsoid, echinulate, pale yellow, 18-22 x 22-26μ. Telia epiphyllous, on yellowish spots, scattered or in groups, covered by the ruptured epidermis, pulverulent, dark brown. Teleutospores globose, subglobose or ellipsoid, apex thickened, papillate, smooth, brown, 18-24 x 25-30μ ; pedicel hyaline, short, deciduous.

On *Aconitum laeve* Royle (=*A. lycoctoni* Hk. f.), Kagan Valley : Saiful Maluk Sar, Aug. 29, 1949. Aecidia collected from the same locality by Shaukat Ali in July 1954.

20. **Uromyces minor** Schroet. in Cohn., Krypt. Fl. Schles., III, I : 310, 1887 ; Syd. Monogr. Ured. 2 : 134 ; Sacc. Syll. Fung. VII : 560 ; Sydow & Ahmad, p. 439.

Aecia hypophyllous or petiolicolous, scattered or in groups. Telia hypophyllous, scattered or in groups, at first covered by the epidermis, then naked, pulverulent, dark brown. Teleutospores globose, subglobose or ovate, apex papillate, smooth or with a few minute warts arranged in rows, brown, 14-18 x 18-24μ ; pedicel hyaline, short.



Uromyces minor, teleutospores.

On *Trifolium resupinatum* Linn., Chillianwala, May 15, 1934 ; Ladhar, Sheikhupura Dist., April 16, 1952, II+III.

21. **Uromyces nerviphilus** (Grognot) Hotson, Publ. Puget Sound Biol. Stat., 4 : 368, 1925.-Syn. *U. flectens* Lagerh. in Bot. Tidskr. 3 : 36, 1909 ; Syd. Monogr. Ured. 2 : 360 ; Sacc. Syll. Fung. XXI : 541.

Telia hypophyllous or petiolicolous, causing swellings, scattered, up to 2 mm. long, dark brown. Teleutospores globose to ovate, apex rounded, papillate, smooth, brown, 18-24 x 20-28μ, epispore 2μ thick ; pedicel short, hyaline.

On *Trifolium repens* Linn., Kagan Valley : Sogran.

22. **Uromyces orientale** Syd. in Annal. Mycol. 5 : 490, 1907 ; Monogr. Ured. 2 : 102 ; Sacc. Syll. Fung. XXI : 547 ; Sydow & Ahmad, p. 439 ; Butler & Bisby, p. 83.

Uredia amphigenous or caulicolous, scattered, pulverulent, cinnamon. Uredospores globose, subglobose or ellipsoid, aculeate, brown, 18-20μ in diameter, epispore 1.5-2μ. Telia compact, black. Teleutospores globose, subglobose or elliptic, apex rounded, much thickened (up to 10μ), smooth, chestnut brown, 20-28 x 24-32μ, epispore 3-5μ thick ; pedicel hyaline, up to 120μ long.

On *Indigofera linifolia* (Linn. f.) Retz., Ladhar, Sheikhupura Dist. ; Gujrat, Punjab (Cheema).

23. **Uromyces phacae-frigidae** (Wahlenb.) Hariot in Jour. de Bot. 7 : 375, 1893 ; Jorstad, p. 82.

Telia densely covering the lower surface of the leaflets, pulverulent, brown. Teleutospores subglobose or ovate, apex minutely papillate, brown, 19-26 x 25-35μ, smooth or with minute warts arranged in rows ; pedicel up to 60μ long, hyaline.

On *Astragalus coluteocarpus* Boiss., Barum Gol : Zapotili, Chitral State, III.

24. **Uromyces polygoni-avicularіae** (Pers.) Karst. Bidr. Kaaned, Finl. Nat. Folk, 4 : 12, 1879.-Syn. *Uromyces polygoni* (Pers.) Fckl. Symb. Myc. p. 64 ; Syd. Monogr. Ured. 2 : 236 ; Sacc. Syll. Fung. VII : 533 ; Malik & Khan, p. 524.

Uredia amphigenous and caulicolous, scattered or in groups, soon naked, pulverulent, cinnamon. Uredospores globose to ellipsoid, verruculose, pale brown, 16-22 x 18-24μ, epispore 1.5-2.5μ thick, germ pores 3 or 4. Telia similar but larger and dark brown. Teleutospores globose or obovate, apex rounded, thickened (up to 6μ), smooth, chestnut brown, 16-22 x 26-36μ ; pedicel tinted, up to 80μ long.

On *Polygonum aviculare* Linn., Kagan Valley : Sharhan, July 26, 1951 ; Quetta Valley, Oct. 15, 1948 ; on *P. viviparum* Linn., Hazara (S. A. Malik) ; Swat State : Madian, Aug. 15, 1952, II+III.

25. **Uromyces proeminens** (DC.) Lev. in Ann. Sci. Nat. Bot. Ser. III, 8 : 371 & 375, 1847 ; Syd. Monogr. Ured. 2 : 158 ; Sacc. Syll. Fung. VII : 553 p.p.

On *Euphorbia hypericifolia* Linn., Gilgit, Aug. 3, 1954, leg. R. R. Stewart ; Muzaffarabad.

26. **Uromyces punctatus** Schroet. Abh. Schles. Ges. Vaterl. Cult. Nat. Abth. 1869-72, p. 10, 1870.-Syn. *U. astragali* (Opiz) Schroet. in Cohn , Krypt. Fl. Schles, III, 1 : 308, 1887 ; Syd. Monogr. Ured. 2 : 67 ; Sacc. Syll. Fung. VII : 550 p.p.

Uredia amphigenous, scattered, pulverulent, cinnamon. Uredospores globose, subglobose or ellipsoid, echinulate, yellowish brown, 16-22 x 18-24μ, epispores 1.5-2.5μ, germ pores 3-4. Telia similar but darker in colour. Teleutospores globose, subglobose or ovate, apex papillate, verrucose, brown, 16-20 x 16-24μ ; pedicel hyaline, short.

On *Oxytropis* sp., Kagan Valley : Batakundi, Aug. 27, 1949 ; Saiful Maluk, Aug. 24, 1954, II+III.

27. **Uromyces rumicis** (Schum.) Wint. in Hedwigia 19 : 37, 1880 ; Syd. Monogr. Ured. 2 : 238 ; Sacc. Syll. Fung. VII : 344; Sydow & Ahmad, p. 439.

Uredia amphigenous, scattered, soon naked, pulverulent, cinnamon. Uredospores subglobose to ellipsoid, echinulate, pale brown, 20-24 x 22-26μ, germ pores 2 or 3. Telia similar but darker in colour. Teleutospores subglobose to pyriform, apex papillate, papilla hemispheric, hyaline, smooth, brown, 20-24 x 28-34μ, pedicel hyaline, deciduous.

On *Rumex dentatus* Linn., Lahore, March 17, 1951 ; Changa Manga ; Chillianwala.

28. **Uromyces setariae-italicae** (Diet.) Yoshino in Bot. Mag. Tokyo 20 : 247, 1906 ; Syd. Monogr. Ured. 2 : 339 ; Sacc. Syll. Fung. XVII : 457 ; Sydow & Ahmad, p. 440.

Uredia amphigenous, scattered or in rows, pulverulent, cinnamon. Uredospores globose, subglobose or ovate, echinulate, yellowish brown, 20-24 x 26-34μ, epispore 1.5μ thick, germ pores 3-4. Telia hypophyllous, dark brown. [Teleutospores globose, ovate or oblong, apex not thickened, rounded or truncate, smooth, yellowish brown, 20-24 x 24-30μ, epispore 2-3μ thick ; pedicel hyaline, short].

On *Setaria lutescens* Hubbard (=*S. glauca* Beauv.), Lahore ; Ladhar, Sheikhupura Dist., Nov. 24, 1951 ; Montgomery, II.

29. **Uromyces striatus** Schroet. in Abhand. Schles. Ges. Vaterl. Culture 1872, p. 11, 1870 ; Syd. Monogr. Ured. 2 : 115 ; Sacc. Syll. Fung. VII : 542 p. p.- Syn. *U. medicaginis* (Pass.) Thuem. Herb. Myc. Oecon. 156, 1874 ,

Uredia amphigenous, scattered, pulverulent, cinnamon. Uredospores globose or ellipsoid, echinulate, yellowish brown, 18-22μ in diam., epispore 1.5-2μ thick, germ pores 3-4. Telia similar but darker. Teleutospores globose, subglobose or ovate, apex papillate, with warts arranged in shorter or longer rows, brown, 18-20 x 20-24μ, epispore 1.5-2μ thick ; pedicel hyaline, short.

On *Medicago sativa* Wall., Ladhar, Sheikhupura Dist. ; Sargodha, Feb. 24, 1934; Chillianwala.-on *M. lupulina* Linn., Poonch, April 18, 1952, leg. R.R. Stewart.-on *M. denticulata* Willd., Chillianwala.

30. **Uromyces striolatus** Tranz. in Annal. Mycol. 8 : 23, 1910 ; Syd. Monogr. Ured. 2 : 175 ; Sacc. Syll. Fung. XXI : 563 ; Jorstad, p. 83.

Pycnia hypophyllous, numerous. Telia arising from a systemic mycelium, forming large pustules, dark brown. Teleutospores ovate or pyriform, apex rounded, papillate, 16-22 x 22-31μ, epispore 1.5-2μ thick, longitudinally striate, pale brown, pedicel hyaline, deciduous.

On *Euphorbia* aff. *esula* Linn., Barum Gol, Chitral State, O+III.

31. **Uromyces superfluus** H. & P. Syd. in Monogr. Ured. 2 : 337 ; Sacc. Syll. Fung. XXI : 593.

Uredia hypophyllous, in rows, long covered by epidermis, ferruginous. Uredospores globose, subglobose or ellipsoid densely verruculose, yellowish brown, 18-20 x 20-24μ, epispore 2-3μ thick. [Telia rare, black. Teleutospores globose, subglobose or ovate, apex rounded, much thickened (up to 9μ), smooth, brown, 19-24 x 22-25μ, epispore 3μ thick ; pedicel hyaline, up to 70μ long.]

On *Panicum antidotale* Retz., Changa Manga, Dec. 12, 1951 ; Karachi, Jan. 23, 1952, II.

32. **Uromyces thallungi** Maire in Bull. Soc. N.H. de L'afr. du Nord. p. 147, 1917 ; Sacc. Syll. Fung. XXIII : 637.

Uredia amphigenous, on purple spots, scattered or gregarious, often circinate, sometimes confluent, long covered by epidermis, pulverulent, cinnamon. Uredospores globose or oval, finely verruculose, 21-27 x 24-33μ, epispore 3μ thick, pale brown, germ pores 2, equatorial. Telia similar but

larger and blackish brown. Teleutospores subglobose, apex rounded, thickened (to 7μ), smooth, brown, 20-24 x 22-28μ ; pedicel hyaline, up to 120μ long.

On *Rumex vesicarius* Linn., Karachi, Sep. 1950, leg. S.M. Jafary, II+III.

33. **Uromyces trifolii** (Hedw. f.) Lev. in Ann. Sci. Nat. Ser. III, 8: 371 ; Syd. Monogr. Ured. 2 : 132 ; Sacc. Syll. Fung. VII : 534 p.p, ; Arth. & Cumm., p. 406 ; Butler & Bisby, p. 84 ; Malik & Khan, p. 524.

Uredia hypophyllous and petiolicolous, scattered or in groups, pulverulent, pale brown. Uredospores globose, ovate or ellipsoid, echinulate, yellowish brown, 18-22 x 20-26μ, epispore 1.5μ thick, germ pores 5-7. Telia dark brown. Teleutospores globose to ovate, apex rounded, papillate, smooth, brown, 16-25 x 18-30μ, epispore 2μ thick ; pedicel hyaline, short.

On *Trifolium resupinatum* Linn., Islamia College, Peshawar (R. R. Stewart) ; Sangla Hill ; Chillianwala ; Peshawar (Shaw).

34. **Uromyces trifolii-repentis** (Cast.) Liro in Act. Sci. Fauna Fl. Fenn. 29 : 15, 1906.- Syd. Monogr. Ured. 2 : 131 ; Sacc. Syll. Fung. XXI : 542.

Aecidia hypophyllous and petiolicolous, in groups. Aecidiospores 14-18 x 17-21μ. Uredospores with 2 equatorial germ pores. Teleutospores as in *U. trifolii*.

On *Trifolium repens* Linn., Kagan Valley ; Gilgit, June 5, 1951, leg. R.R. Stewart.

35. **Uromyces tuberculatus** Fckl., Symb. Myc. p. 64 ; Syd. Monogr. Ured. 2 : 165 ; Sacc. Syll. Fung. VII : 553, as *U. proeminens* p.p.

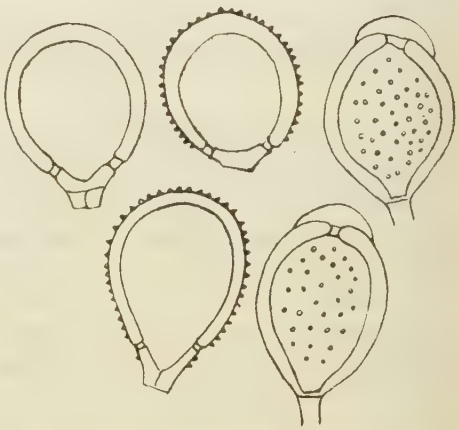
Uredia hypophyllous, scattered, cinnamon. Uredospores globose, yellowish brown, aculeate, 20-25μ in diameter, epispore 1.5-2.5μ thick, germ pores 5-7. Telia amphigenous and culmicolous, scattered or confluent to form large black masses. Teleutospores globose to ellipsoid, apex papillate, smooth or covered with scattered, conical, obtuse warts, chestnut brown, 18-24 x 20-30μ, epispore 2-2.5μ thick ; pedicel hyaline, deciduous.

On *Euphorbia* sp., Quetta, May 14, 1954, leg. Asghar Ali, II+III.

The most common host in Europe is *Euphorbia exigus*, but it has been reported from Kirgizia on *E. franchetii* and a few times from Iran on *Euphorbia* sp.

36. **Uromyces valerianae-wallichii** (Diet.) Arth. & Cumm. in Mycologia 25 : 406, 1933.

Uredia amphigenous, on pale spots, scattered or in small groups, covered by the ruptured epidermis, pulverulent, cinnamon brown. Uredospores globose, ovate or lageniform, yellowish, 22-25 x 23-32μ, germ pores 2, near the hilum. Telia epiphyllous, scattered or in circinate groups, pulverulent, chocolate brown. Teleutospores subglobose or obovoid, 16-22 x 24-30μ, apex rounded, not thickened, covered with scattered, obtuse warts, epispore 2.5-3.5μ thick, chestnut brown; pedicel hyaline, short, deciduous.



Uromyces valerianae-wallichii, teleutospores.

On *Valeriana wallichii* DC., Changla Gali, Murree Hills, Sep. 23, 1949, III ; Kagan Valley : Shogran, July 16, 1951, II.

Uredo Pers.

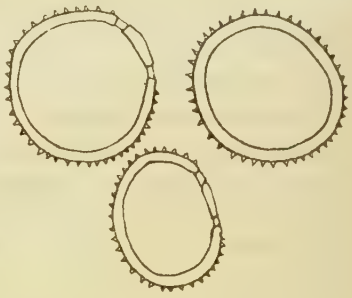
1. **Uredo dalbergiae** P. Henn. in Hedwigia 34, p. 98, 1895 ; syd. Monogr. Ured. 4 : 476 ; Sacc. Syll. Fung. XVII : 445.

On *Dalbergia sissoo* Roxb., Change Manga.

2. **Uredo otostegiae** sp. nov.

Soris hypophyllous, dispersis vel confluentibus, rotundatis vel ellipsoidibus, tandem late apertis et pulverulentis, brunneis. Sporis globosis vel subglobosis, echinulatis, flavo-brunneis, 20-30μ diam., poris germ. 2, hilo proximis.

Hab. in foliis *Otostegiae limbatae*, Kagan Valley : Balakot, 16.4.55, no, 14057. Typus depositus in Heb. C.M.I.



Uredo otostegiae, teleutospores.

Uredia hypophyllous, scattered or confluent, medium to large, rounded or oblong, soon naked, pulverulent, chestnut brown. Spores globose or subglobose, echinulate, yellowish brown, 20-30μ in diam., with 2 germ pores near the hilum.

On *Otostegia limbata* Benth., Balakot ; Poonch (R. R. Stewart).

3. **Uredo ravennae** Maire in Bull. Soc. d'Hist. Nat. de l'Afrique Nord 8 : 153, 1917 ; Syd. Monogr. Ured. 4 : 538.

Uredia hypophyllous, rarely epiphyllous, linear, up to 3 mm. long, soon naked, pulverulent, ferruginous ; paraphyses absent. Uredospores subglobose, ellipsoid, ovate or pyriform, finely echinulate, yellowish brown, 24-28 x 30-40μ, germ pores 3-4, equatorial.

On *Erianthus ravennae* Beauv., Chuharkana ; Lahore.

A very common rust usually confused with uredo-stage of *Puccinia kuehnii* due to the wrong identification of the host. In the present rust paraphyses around the uredia are lacking while in the other 2-celled clavate or cylindric paraphyses are present.

4. **Uredo rottboelliae** Diet. in Engler. Bot. Jahrb. 32: 52, 1902; Syd. Monogr. Ured. 4 : 546 ; Sacc. Syll. Fung. XVII : 457.

On *Hemarthria compressa* (Linn.) Br., Lahore ; Changa Manga ; Sangla Hill. Very common.

5. **Uredo vicatiae** Syd. in Annal. Mycol. 5 : 508, 1907 ; Monogr. Ured. 4 : 441 ; Sacc. Syll. Fung. XXI : 789.

Uredia hypophyllous, without spots, scattered, minute, soon naked, pulverulent, cinnamon. Uredospores globose, subglobose or ovate, echinulate, yellowish brown, 15-20 x 18-25μ, apex thickened (4-6μ), germ pores 2-3, provided with a broad, hyaline papilla.

On *Vicatia coniifolia* DC., Poonch, leg. R.R. Stewart, July 1952.

Peridermium Link

1. **Peridermium indicum** Colley & Taylor in Jour. Agric. Res. 34 : 329, 1927 ; Malik & Khan, p. 523.

On *Pinus excelsa* Wall., Hazara (S.A. Malik).

2. **Peridermium thomsoni** Berk. apud Cooke in Indian Forester 3 : 94, 1877 ; Syd. Monogr. Ured. 4 : 4 ; Sacc. Syll. Fung. VII : 837.

On leaves of *Picea morinda* Link, Kagan Valley : Sharhan, July 27, 1951.

"It resembles considerably *P. corruscans* Fr., which is the aecidial stage of *Chrysomyxa woronini* Tranz. But as *Ledum* does not grow in West Pakistan, naturally *P. thomsoni* must be at least physiologically distinct from *Chr. woronini*." Jorstad.

Monosporidium Barcl.

1. **Monosporidium andrachnis** Barcl. in Jour. Asiatic Soc. Bengal

56 : 364, 1887 ; Syd. Monogr. Ured. 4 : 364 ; Sacc. Syll. Fung. IX : 297 ; Malik & Khan, p. 523.

On *Andrachne cordifolia* Muell., Changla Gali, August 13, 1954 ; Murree Hills, August 1948.

"The spermogonia are subcuticular, as recently discovered by Thirumalachar & Kern (Torr. Bot. Club. Boll. 1955, p. 106). Provisionally this may justify the maintenance of the genus *Monosporidium*." Jorstad.

1. **Aecidium callianthum** Syd. in Annal. Mycol. 33 : 54. 1935 ; Malik & Khan, p. 523.

On *Desmodium tilliaefolium* G. Don, Hazara (R.R. Stewart).

2. **Aecidium clematidis** DC.

On *Clematis* sp., Kagan Valley : Sharhan, July 25, 1951.

According to Arthur (Jour. Myc. 11 : 63, 1905) it belongs to *Puccinia agropyri* Ell. & Ev.

3. **Aecidium colchici** sp. nov.

Aecidia hypophyllis, maculis orbicularibus, 5mm. diam. habitantes, aggregatis, cupulatis, cellulis peridii rhomboidibus, 17-22 x 19-37μ, pariete striato, 8-10μ crasso, verrucoso, 2-4.5μ crasso. Sporis globosis vel angulo-globosis, 13-16 x 16-22μ, epispori 1.5-2μ crasso, flavo-brunneo.

Hab. in foliis *Colchici lutei*, Murree, Upper Topa, June 15, 1951, no. 4532, type. Typus depositus in Herb. C.M.I.

Aecia hypophyllous, on orbicular spots, 5-8 mm., gregarious, cupulate, peridial cells rhomboidal, 17-22 x 19-37μ, outer wall 8-10μ thick, striate, inner 2-4.5μ thick, verrucose. Spores globose or angulo-globose, 13-16 x 16-22μ, epispore 1.5-2μ thick, yellowish brown, verrucose.

On leaves of *Colchicum luteum* Baker, Murree, Upper Topa, leg. I.I. Chaudhuri, June 15, 1951, no. 4532, type. Abbottabad, leg. A. H. Khan, April 14, 1952.

Only one *Aecidium* has previously been described on *Colchicum*, viz., *Ae. colchici-aurei* Uelbrich on *Colchicum aureum* in Kashmir (Notizbl. Bot. Gart. u. Mus. Berlin-Dahlem, 14 p. 150, 1938) but in this the aecidia and aecidiospores are much larger than in the present species, besides the aecidiospores are yellowish brown. The host of *Ae. colchici-aurei* was misdetermined by Uelbrich as *C. aureum*. In the Himalayas only one species of *Colchicum*, viz., *C. luteum* Baker is found and it harbours two different species of *Aecidium*.

4. **Aecidium crypticum** Kalchbr. & Cke. in Grevillea 9 : 21, 1880 ;

Syd. Monogr. Ured. 4 : 41 ; Sacc. Syll. Fung. VII : 900 ; Arth. & Cumm., p. 398 ; Malik & Khan, p. 523.

On *Gerbera lanuginosa* Hk. f. (=*G. gossypina* (Royle) Beauv.), Kagan Valley : Shogran, 21.8.49, Ghora Gali, Murree Hills ; Swat State.

"This aecidium is described from South Africa, and belongs to *Puccinia gerberae* Pole Evans, on various species of *Gerbera* in South Africa where the teleuto-stage does not appear to be scarce, and is, in fact, present in the type material of *Ae. crypticum* (acc. to Doidge). As in the Himalayas aecidia only have been found, their belonging to *P. gerberae* seems very unlikely ; they may perhaps belong to a heteroecious species." Jorstad.

5. **Aecidium euphorbiae** Gmel. ex Pers. Syn. Meth. Fung., p. 211, 1801.

On *Euphorbia* aff. *esula* Linn., Barum Valley, Chitral State ; on *Euphorbia* sp., Kagan Valley : Naran, leg. I.I. Chaudhuri.

6. **Aecidium hederae** Wakefield in Bull. Misc. Inf. Kew 1931 : 202, 1931.- Syn. *Ae. hederae* Arth. & Cummins in Mycologia 25 : 398, 1933 ; Cummins, p. 446.

On *Hedera nepalensis* K. Koch (=*H. helix* Hk. f.), Murree, April 1951.

7. **Aecidium merenderae** Syd. in Annal. Mycol. 4 : 441, 1906 ; Syd. Monogr. Ured. 4 : 286 ; Sacc. Syll. Fung. XXI : 784.

On *Merendera persica* Boiss. (=*M. aitchisoni* Hk. f.), Salt Range (Drummond).

8. **Aecidium montanum** Butl. in Indian Forester 1905, p. 30 ; Syd. Monogr. Ured. 4 : 248 ; Sacc. Syll. Fung. XXI : 753 ; Arth. & Cumm., p. 399 ; Cummins, p. 447.

a. LOCALIZED PHASE :

On *Berberis ceratophylla* G. Don, Murree ; on *B. petiolaris* Wall., Murree ; Nathia Gali ; Changla Gali ; Kagan Valley : Shogran.

b. SYSTEMIC PHASE :

On *Berberis* sp., Barum Valley, Chitral State, leg. I.I. Chaudhuri, June 28, 1950.

On *Berberis vulgaris*, Ziarat, Baluchistan, July 12, 1951.

"I do not think it unlikely that the systemic aecidial stage from Barum Valley belongs to *P. arrhenatheri* Eriks., which is known from Russian Central Asia, on various species of *Berberis*, and which I think belongs to the grass rust *P. poae-nemoralis* Otth. s. lat. However, in *P.*

arrhenatheri the aecidia solely raise from a systemic mycelium, not from a localized one, as allegedly in *Ae. montanum.''* Jorstad.

Dr Emil Mueller writes to inform that recently Parsad has proved that *Ae. montanum* Butl. belongs to *Puccinia graminis* var. *agropyri* Parsad. The writer has no access to Parsad's paper but it is probable that he was dealing with the localized phase of *Ae. motanum.*

9. **Aecidium orbiculare** Barcl. in Jour. Asiatic Soc. Bengal 60 : 227, 1191 ; Syd. Monogr. Ured. 4 : 256 ; Sacc. Syll. Fung. XI : 213.

On *Clematis* sp., Gilgit, June 5, 1951 (I.I. Chaudhuri).

10. **Aecidium ranunculacearum** DC.- Syn. *Ae. aconiti-napelli* (DC.) Wint. in Pilze Deutschl. 1881, p. 268 ; Syd. Monogr. Ured. 4 : 348 ; Cummins, p. 447

On *Heracleum candicans* Wall., Kishenganga Valley (R. R. Stewart) ; Kagan Valley : Nadi-Kund, 28.7.51.

According to Cummins (l.c.) the apically thickened wall of the aeciospores distinguish this species from other aecial forms on *Heracleum.*

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Euphorbia falcata
Melampsora euphorbiae-gerardianae
Euphorbia helioscopia
Melampsora euphorbiae
Euphorbia hypericifolia
Melampsora euphorbiae
Uromyces proeminens
Euphorbia kanaorica
Melampsora euphorbiae
Euphorbia thomsoniana
Melampsora euphorbiae
Ficus palmata
Cerotelium fici
Fimbristylis dichotoma
Puccinia flavipes
Fritillaria roylei
Uromyces fritillariae
Galium aparine
Puccinia ambigua
Gentiana kurroo
Puccinia gentianae

Geranium aconitifolium
Uromyces geranii
Geranium collinum
Puccinia leveillii
Geranium collinum var. eglandulosum
Puccinia leveillii
Geranium pratense
Puccinia leveillii
Geranium rectum
Puccinia leveillii
P. polygoni-amphibii
Geranium wallichii
Puccinia polygoni-amphibii
Gerbera gossypina
Aecidium crypticum
Gueldenstaedtia sp.
Uromyces kondoi
Haloxylon recurvum
Uromyces heteromallus
Hedera nepalensis
Aecidium hederae
Hedera helix
(see Hedera nepalensis)
Helianthus annuus
Puccinia helianthi
Hemarthria compressa
Uredo rottboelliae
Heracleum candicans
Aecidium stewartianum
Puccinia heraclei
Heracleum thomsoni var. glabior
Puccinia heracleicola
Heteropogon contortus
Puccinia versicolor
Hieracium vulgatum
Puccinia hieracii
Hordeum vulgare
Puccinia graminis
Impatiens sp.
Puccinia komarovi
Impatiens brachycentra
Puccinia argentata
Imperata cylindrica
Puccinia rufipes
Indigofera linifolia
Uromyces orientalis
Iris germanica
Puccinia iridis
Juncus sp.
Puccinia junci
Lactuca brunoniana
Puccinia prenanthes var. *himalensis*
Lamium rhomboideum
Puccinia phlomidis
Lathyrus aphaca
Uromyces fabae
Lathyrus odoratus
Uromyces fabae
Launaea as plenifolia
Puccinia butleri
Launaea nudicaulis
Puccinia butleri
Lavatera kashmiriana
Endophyllum tuberculatus
Lepidium draba
Puccinia isiacae
Lespedeza sericea
Uromyces lespedezae-sericeae
Linum usitatisimum
Melampsora lini
Lolium perenne
Puccinia rubigo-vera
Lonicera asperifolia
Puccinia longirostris
Lycium europeum
Puccinia turgida
Medicago denticulata
Uromyces striatus
Medicago lupulina
Uromyces striatus
Medicago sativa
Uromyces striatus
Mentha sylvestris
Puccinia menthae
Merendera persica
Aecidium merenderae
Mimosa himalayana
Ravenelia mimosae-himalayae
Nepeta sp.
Puccinia menthae
Oenanthe stolonifera
Puccinia oenanthes
Origanum vulgare
Puccinia menthae
Otostegia limbata
Uredo otostegiae
Oxytropis sp.
Uromyces punctatus
Panicum antidotale
Uromyces superfluus
Peucedanum aucheri
Puccinia bullata
Phalaris minor
Puccinia striaeformis
Phragmites karka
Puccinia invenusta
P. isiacae

Picea morinda
Chrysomyxa deformans
Peridermium thomsoni
Pucciniastrum areolatum
Pimpinella diversifolia
Puccinia pimpinellae
Pisum sativum
Uromyces fabae
Plantago lanceolata
Puccinia cynodontis
Pleurospermum stylosum
Puccinia chitralensis
Poa annua
Puccinia poarum
Polygonum sp.
Puccinia solmsii
Polygonum aviculare
Uromyces polygoni-avicularіae
Polygonum amplexicaule var. speciosum
Puccinia jorstadi
Polygonum pterocarpum
Puccinia polygoni-amphibii
Polygonum viviparum
Uromyces polygoni-avicularіae
Populus alba
Melampsora populnea
Populus ciliata
Melampsora ciliata
Potentilla argentea
Phragmidium potentillae
Potentilla argyrophylla
Phragmidium laceianum
Potentilla kleiniana
Phragmidium potentillae
Potentilla nepalensis
Phragmidium nepalensis
Phr. papillatum
Phr. potentillae
Prenanthes brunoniana
(see Lactuca brunoniana)
Prunus persica
Puccinia pruni-spinosae
Ranunculus falcatus
Puccinia ranunculi-falcatae
Ranunculus hirtellus
Aecidium ranunculacearum
Rhamnus dahuricus
Puccinia coronata
Rhamnus virgatus
Puccinia coronata
Ribes rubrum
Cronartium ribicola
Puccinia ribis
Rosa sp.
Phragmidium butleri
Phr. mucronatum
Rosa centifolia
Phragmidium rosae-moschatae
Rosa macrophylla
Phragmidium butleri
Rosa moschata
Phragmidium rosae-moschatae
Rosa webbiana
Phragmidium kamtschatke
Phr. rosae-moschatae
Phr. tuberculatum
Rubia cordifolia
Puccinia collettiana
Rubus sp.
Phragmidium shogranense
Rubus lasiocarpus
Phragmidium barclayi
Rubus niveus
Phragmidium mysorensis
Phr. shogranense
Rumex dentatus
Uromyces rumicis
Rumex nepalensis
Puccinia nepalensis
Rumex orientalis
Puccinia acetosae
Rumex vesicarius
Uromyces thallungi
Saccharum arundinaceum
(see S. munja)
Saccharum munja
Puccinia kuehnii
Saccharum spontaneum
Puccinia kuehnii
Salix sp.
Melampsora epitea
Salix acmophylla
Melampsora salicis-albae
Salix hastata
Melampsora epitea
Salvia hydrangea
Puccinia bithynica
Saxifraga ciliata
Puccinia saxifragae-ciliatae
Saxifraga stracheyi
Puccinia saxifragae-ciliatae
Scirpus littoralis
Puccinia scirpi
Scirpus maritimus
Uromyces lineolatus

Sedum heterodontum
Puccinia umblici
Selinum papyraceum
Puccinia ligustica
Serratula pallida
Puccinia schirajewskii
Setaria glauca
(see S. lutescens)
Setaria lutescens
Uromyces setariae-italicae
Solidago virga-aurea
Puccinia extensicola
Sonchus arvensis
Puccinia sonchi
Sorghum halepense
Puccinia purpurea
Sorghum vulgare
Puccinia purpurea
Sporobolus marginatus
Uromyces ignobilis
Strobilanthes dalhousianus
Puccinia pollinia
Suaeda fruticosa
Uromyces chenopodii
Swertia petiolata
Puccinia swertiae
Swertia speciosa
Puccinia swertiae
Swertia thomsoni
Puccinia swertiae
Taraxacum officinale
Puccinia silvatica
Puccinia taraxaci
Tragapogon sp.
Puccinia hysterium
Tricholepis stewartii
Puccinia tricholepidis
Trifolium repens
Uromyces nerviphilus
U. trifolii-repentis
Trifolium resupinatum
Uromyces minor
U. trifolii
Trigonella gracilis
Uromyces anthyllidis
Trigonella incisa
Uromyces anthyllidis
Trigonella polycerata
(see T. incisa).
Triticum aestivum
Puccinia graminis
P. rubigo-vera
P. striaeformis
Tulipa stellata
Puccinia prostii
Urtica dioica
Puccinia caricis
P. urticae
Valeriana wallichii
Uromyces valerianae-wallichii
Vicia faba
Uromyces fabae
Vicia sativa
Uromyces fabae
Vicatia coniifolia
Uredo vicatiae
Viola caespitosa
Puccinia violae
Viola cenescens
Puccinia violae
Viola serpens
Puccinia violae
Zea mays
Puccinia maydis
Zizyphus jujuba
Phakopsora zizyphi-vulgaris
Zizyphus nummularia
Phakopsora zizyphi-vulgaris
Zizyphus sativa
Phakopsora zizyphi-vulgaris
Zizyphus vulgaris
(see Z. sativa)

Studies on *Bruelia* species (Mallophaga) occurring on True Thrushes

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INTRODUCTION

Although over one hundred and twenty five species of *Bruelia* are now recognized (Hopkins & Clay, 1952), yet there is no paper containing a comprehensive systematic treatment of the species infesting any one bird-host group. This has probably been due in part to the difficulty in obtaining sufficient material from one host group, and to the brevity of the published descriptions. An attempt has been made in this paper to present a complete revision of almost all the known *Bruelia* species parasitic on True Thrushes (True Thrushes as defined by Ripley, 1952).

The present paper is based on the collection of Col. R. Meinertzhagen in the British Museum (Natural History), except where indicated otherwise in the text. The camera lucida drawings were made from microscopic slides. The male genitalia, when dissected and mounted, naturally did not retain their original appearance because the coverglass flattened them to some extent. This fact should be borne in mind when these drawings are interpreted. All the linear measurements were taken along the mid-line. The length of the preantennal region represents the distance between the front and the point passing through the posterior margin of the conus and the length beyond is represented by the hind-head. The width represents the maximum transverse measurement of the part concerned. The index (cephalic, preantennal and hind head) is the ratio of the length to the width.

All the specimens including *holotype* (male), *allotype* (female) and *paratypes* (males and females) are in the Collection of the British Museum (Natural History), London. Instances not relating to such cases are indicated in the text.

TAXONOMIC CHARACTERS

As to what character or characters may be classed as of specific or subspecific importance, will always remain controversial. The *Bruelia*

species in particular present special problems of their own. There is no constant feature which can be used to separate the various species. Males and females of all the species show more or less difference in abdominal chaetotaxy but exhibit very little sexual dimorphism. Females of several species are identical and it is frequently most difficult to assign a particular female specimen to the proper species unless the evidence is at hand to demonstrate that it was collected from the same host as carried the opposite sex also. Males of most species are easily distinguishable. By employing suitable sets of characters, it is possible to distinguish groups of males corresponding to similar groups of females. The following principal morphological characters of the males were found helpful for splitting the various species and subspecies.

HEAD : Thimble-shaped, conical or triangular like fir-cone, with rounded or truncate front. Sides straight or slightly convex, temporal lobes regularly sloping or strongly diverging, proportion of preantennal region and hind-head always constant in allied forms. Characters of the marginal and ventral carinae variable in the different groups. Other modifications of the frontal region of special significance.

THORAX : The shape of the prothorax is almost constant, but the variations howsoever small, deserve consideration. The pterothorax is more or less trapezoidal in shape; the degree of its divergence, the point of origin of the abdominal segments, and the posterior chaetotaxy are important.

ABDOMEN : The tergal plates are found to be more or less of uniform pattern. The sculpture of the tergal plates, however, varies and provides an additional character for the identification of species. The chaetotaxy is of great importance. Male genital armature is of particular interest : it provides the most stable character, and should invariably be checked in each species. Although it may be very similar throughout a group of species, it differs considerably in its details. In females the subgenital and vulvar plates and the marginal chaetotaxy, though similar in closely allied forms, may sometimes provide additional characters for the differentiation of species and separation of subspecies.

Apart from individual variations, which are of universal occurrence, several species contain subspecies which breed on separate hosts. Many Mallophagologists perfer to give no names to these forms. They probably believe that providing names to these forms complicates the taxonomic system. Others assign a different name to each form. Colless (1954) urges that the term subspecies should not be used as a waste paper basket for controversial forms. In my opinion, this principle, if adopted widely

by workers, will prevent lumping closely allied groups and thus help in the separation of distinctly varient forms in the same species.

According to the general form of the body and head, the *Bruelia* species from the True Thrushes fall into three distinct groups. These groups with their salient distinguishing characters are given below.

(i) The *iliaci* group : This category embraces very fragile and feebly sclerotized species. They are similar to *Bruelia deficience* (Piaget) described from *Cyanopica cyanus cooki* Boneparte (Corvidae). The head is longer than broad (cephalic index=1 : 0.79-0.85). *Bruelia iliaci, B. iliaci brevicolor,* and *B. iliaci indiensis* fall in this group.

(ii) The *marginata* group : This class includes small species (males 1.23-1.62 mm. long). The head is almost as long as broad (cephalic index=1 : 0.97-1.08). The forehead is either narrow and elongate or the clypeal region is rounded. The abdominal chaetotaxy is of two patterns. The parameres are of the shape of a knife blade. *Bruelia longifrons, B. longifrons antiqua, B. myiophoneae, B. marginata, B. viscivori, B. amsel, B. oudhensis, B. turdinulae, B. turdinulae eternitatus* and *B. ilmasae* are included in this group.

(iii) The *merulensis* group : These are robust species (males 2.11-2.35 mm. long). Head is always longer than broad. Parameres are typical, 'kukri shaped'. *B. stresemanni, B. zootherae, B. daumae* and *B. merulensis* belong to this group.

ACKNOWLEDGEMENTS

I am greatly indebted to Miss T. Clay of the British Museum (Natural History) for the loan of the material, for kind assistance in many ways without which this revision would have not been possible, and for editing the manuscript. My thanks are also due to Mr Saleim Rahman and Mlle. Athar for their help in the preparation of the figures.

SYSTEMATIC ACCOUNT

KEY TO THE SPECIES

The following key is based almost entirely on the males of the species discussed in the text. As has already been said elsewhere the females of most species are indistinguishable and cannot be used to separate the species.

1 (8) Marginal carinae entire laterally and indented medially. Anterior margin of head at the interrupted point hyaline. Triangular area of sclerotization in the indented part of the marginal carina present.

2 (7) Delicate species, very feebly sclerotized. Head conical, of the

shape of a fir-cone or a thimble. Ocular carina narrow. Greatest width of the head considerably smaller than the total length. Cephalic index 1 : 0.77-0.87, index of preantennal region 1 : 1.24-1.37. Male genitalia feeble. Parameres rather short and slender, tapering gradually to the tips. (Female genital plate furnished with 7-9 short setae).

3 (6) Mesosome 20-30 percent wider than long. (Subgenital plate in female twice as wide posteriorly as in *Bruelia indiensis*).

4 (5) VII tergal plate with 2, VIII with 3 setae on each side..... .....*Bruelia iliaci* (Denny)

5 (4) VII tergal plate with 2+3, VIII with 1+5 setae on each side ..... *Bruelia iliaci brevicolor* subsp. nov.

6 (3) Mesosome as long as broad. (Subgenital plate in female narrow posteriorly).....*Bruelia iliaci indiensis* subsp. nov.

7 (2) Robust species, moderately sclerotized. Head triangular, of the shape of a squat crucible. Greatest width of the head 25 percent more than the total length. Cephalic index 1 : 1.20-1.22, index of the preantennal region 1 : 1.88-1.95. Male genitalia well-built. Parameres 'kukri-shaped' resembling the wing of 'samara' of common maple. (Female genital plate furnished with 12 thick and 10 long setae) .... *Bruelia stresemanni* (Clay)

8 (1) Marginal carina interrupted medially and laterally.

9 (2) Parameres well developed, 'kukri-shaped', resembling the wing of 'samara' of common maple.

10 (13) Head more or less rounded in front, preantennal region with convex sides. Basal plate considerably convex in the middle. Mesosome more or less as wide as long or very slightly wider than long, (1 : 1.05-1.17).

11 (12) Head comparatively squat, narrowly parabolic in front. Basal plate about four times as long as mesosome, (3.96 : 1)..... ..... *Bruelia zootherae* (Clay)

12 (11) Head narrow in front, broadly parabolic in front. Basal plate about six times as long as mesosome, (5.59 : 1) .... *Bruelia daumae* (Clay)

13 (10) Preantennal region with straight sides. Basal plate more or less straight. Mesosome considerably wider than long,

(1 : 1.49). Basal plate 5.05 times as long as mesosome.....
.....*Bruelia merulensis* (Denny)

14 (9) Parameres well developed, but never 'kukri-shaped'.

15 (20) Head truncate, preantennal region with slightly concave sides.

16 (19) Parameres pointed. Mesosome pointed posteriorly. (Subgenital plate in female moderately acute posteriorly). (Male 1.23-1.26 x 0.41-0.46 mm., female 1.63-1.77 x 0.45-0.55 mm.).

17 (18) Parameres shorter than broad, proximal heads with deep anterior socket. Mesosome with well developed median apophysis. (Subgenital plate in female pointed posteriorly)
.....*Bruelia longifrons* sp. nov.

18 (17) Parameres longer and narrower, proximal heads with a shallow anterior socket. Mesosome shield-shaped, without median apophysis. (Subgenital plate in female comparatively blunt posteriorly).....*Bruelia longifrons antiqua* subsp. nov.

19 (16) Parameres slender, tapering gradually to the blunt tip. Proximal head well developed, extending considerably within mesosome. Mesosome obtuse posteriorly. (Subgenital plate in female blunt posteriorly). Comparatively robust species (male 1.92x0.66 mm. and female 2.27 x 0.76 mm.).....*Bruelia myiophoneae* (Clay)

20 (15) Head more or less thimble-shaped, preantennal region with slightly convex sides.

21 (26) Basal plate 3.5-4.5 times as long as the mesosome.

22 (25) Basal plate not more than 1.7 times as long as broad. Hind-head twice as wide as long (1 : 2). Mesosome elongate.

23 (24) Basal plate five times as long as the parameres. Parameres 0.0035 mm. long, blunt at the tip. Cross-piece of the anchor (sub-genital plate in female) arched like the segment of a circle (Boomerang).....*Bruelia turdinulae* sp. nov.

24 (23) Basal plate four-times as long as the parameres. Parameres 0.0055 mm. long, pointed at the tip. Cross-piece of the anchor flatly arched.....*Bruelia turdinulae eternitatus* sp. nov.

25 (22) Basal plate 2.38 times as long as broad. Hind-head less than twice as broad as long (1 : 1.84). Mesosome squat.....
.....*Bruelia oudhensis* sp. nov.

26 (21) Basal plate 2.05-2.91 times as long as the mesosome.

27 (32) Abdominal segments V-VII with 2+1+1+2 setae. Basal plate twice as long as its greatest width.

28 (31) Preantennal region 1.74-1.77 times as wide as long.

29 (30) Mesosome obtuse posteriorly. Postero-lateral slope regular. Vulvar plate in female with 8-10 setae on each side of the posterior margin.....*Bruelia marginata* (Burmeister)

30 (29) Mesosome acute posteriorly. Postero-lateral slope abrupt. Vulvar plate in female with 5-6 setae on each side.....*Bruelia amsel* (Eichler)

31 (28) Preantennal region 1.9 times as wide as long.....*Bruelia viscivori* (Denny)

32 (27) Abdominal segments V-VII with 1+1+1+1 setae. Basal plate 1.75 times as long as its greatest width.....*Bruelia ilmasae* sp. nov.

1. Bruelia iliaci (Denny)

(Text-figs. 1-7)

Nirmus iliaci Denny, 1842, *Mon. Anopl. Brit.*, 51, 130, pl. 9, fig. 4.

TYPE-HOST : *Turdus musicus musicus* Linn.

MALE : 1.65 x 0.43 mm. Delicate and feebly sclerotized. Head 0.36 x 0.31 mm ; cephalic index 1 : 0.86. Lateral margins of clypeal region moderately convex. Marginal carina narrow, indented medially. Anterior margin of the head at this point hyaline. Dorsal anterior plate V-shaped, with fairly acute posterior angle. Pre-antennal region 0.20 x 0.27 mm. (index 1 : 1.35). Hind-head 0.16 x 0.31 (index 1 : 1.94). Antennae showing sexual dimorphism. The number and arrangement of cephalic setae as described by Clay (1951).

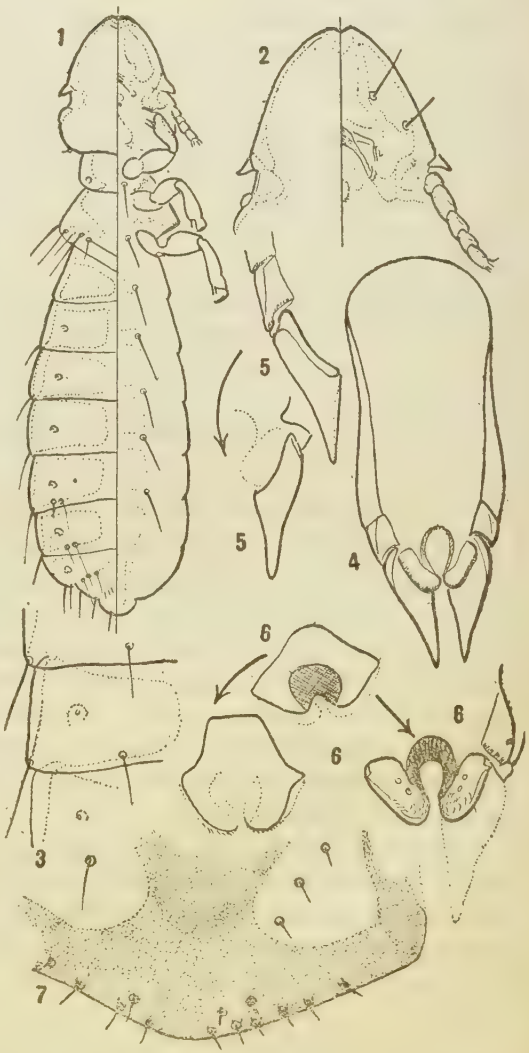
Prothorax 0.11 x 0.20 mm., transverse, lateral margins strongly convex, postero-lateral angle with a short seta. Pterothorax 0.15 x 0.33 mm., median posterior angle well marked, obtusely angulate over abdomen. Latero-posterior angle with one small and one long seta followed by four (sometimes five) rather long setae arranged along the latero-posterior margin.

Abdomen 1.03 x 0.43 mm., widest at the 5th-6th segments. Tergal plates rather yellowish brown ; tergal plates II-VIII completely divided on the middle line ; IX entire ; II-V bare ; VI-VII with two, VIII with three and IX with four setae on each side. Pleural plates feeble, posterior setae slender and moderately long ; II bare ; III-VI and IX-X with one, VII with two, VIII with four setae. Sternal plates well formed, confined on the middle ; II-VI quadrate, VII-XI fused to form an elongate triangular piece. Sternites II-VI bearing on each side a single seta.

Genitalia 0.0179 mm. long. Basal plate 0.0132 mm. long, anterior width 0.0069 mm., posterior width 0.0058 mm. with slight convexity in the anterior half. Parameres rather short, 0.0051 mm. long, proximal head simple as shown in the figure. Mesosome shield-like, 0.0030 x 0.0039 mm. (about 30 percent wider than long).

REMARKS: The male resembles *B. deficiens* from *Cyanopica cyanus cooki* Bonepart in general body form and built. The male genital armature is also of the same pattern.

FEMALE: Similar to male, 1.89 x 0.48 mm. Head 0.38 x 0.32 mm.; cephalic index 1 : 0.84. Preantennal region 0.19 x 0.28 mm. (index 1 : 1.37). Hind-head 0.19 x 0.32 mm. (index 1 : 1.68). Prothorax 0.10 x 0.22 mm. Pterothorax 0.18 x 0.39 mm. Abdomen 1.23 x 0.48 mm. Dorsal chaetotaxy showing sexual variation, brief. VI-VIII tergites with one moderately long seta on each side; IX with three such setae on each side; II pleurite bare; III with one, IV-VIII with two, VIII with four, IX with 1+4 and X-XI with one very short seta. Ventral surface of the terminal segments with



Text-figs. 1-7. *Bruelia iliaci* (Denny): (1) Dorsal and ventral aspects of male; (2) dorsal and ventral aspects of the preantennal region showing the carinae; (3) a portion of the abdomen showing tergal plates; (4) male genital armature; (5) two aspects of parameres; (6) various aspects of mesosome; (7) a portion of the subgenital plate of the female showing the marginal chaetotaxy.

a conical sclerotization placed on a meniscus-like cross piece round the edge of the vulva so as to form an anchor-shaped plate. The posterior end of the conical sclerotization considerably obtuse. Vulvar plate with 8-9 marginal setae.

MATERIAL EXAMINED : 3 males and 3 females from *Turdus musicus musicus* Linn. (Meinertzhagen Collection, Cornwall, March 1946).

REMARKS : Denny (1842, p. 52), in the original description of *Nirmus iliaci*, gave the Redwing (*Turdus iliacus*) as the host. Later, on page 131 of the same publication, Denny stated that he had observed the specimens from the Redwing as well as from the rose-coloured Starling (*Pastor roseus* =*Sturnus roseus*).

In the Denny Collection (in British Museum (Nat. Hist.): Thompson, 1937) there are four specimens (1 male, 2 females, 1 nymph) labelled *Degeeriella iliaci* Denny (1842) from Redwing (*Turdus iliacus*). Miss T. Clay informs me that when the Denny Collection was mounted on slides, all the specimens were re-labelled and the original labels are now lost. It is, therefore, not known how these specimens were originally labelled ; perhaps just with the word "*iliaci*", but certainly neither as 'types' nor with the wording of the present labels. These specimens belong to the species found on *Sturnus roseus* (Linn.) and not to the one found on *Turdus musicus musicus*. Although Denny's figure, in the shape of the head, is certainly more like the species from *Sturnus* than that from *Turdus*, yet this is probably more by chance than by intention. Denny's figures rarely resemble, with any accuracy, the specimens from which they were drawn. In this case the figures only suggest the species from *Sturnus* since they depict the preantennal region as somewhat long and narrow. If we accept the principle of page priority, then *Turdus iliacus* was the only host mentioned in the original description, and the hosts which Denny mentioned on page 131 are irrelevant. The fact that Denny gave the species the name *iliaci* and that this name has always been used for the *Bruelia* of the Redwing (Thompson, 1837 ; Hopkins & Clay, 1952), may justify the restriction of host. In order to settle this confusion, and to ensure against later changes of the name, a neotype will be erected for *Nirmus iliaci* as follows.

NEOTYPE : Male in the British Museum (Natural History), slide No. 15643, figures from *Turdus musicus musicus* Linn. ALLOTYPE (female) in the British Museum (Natural History), slide No. 15643. NEOPARATYPES (3 males and 3 females) in Meinertzhagen Collection (Cornwall, March 1946, slide No. 15643).

Miss Clay sent me some specimens of *Bruelia inornata* Timmermann

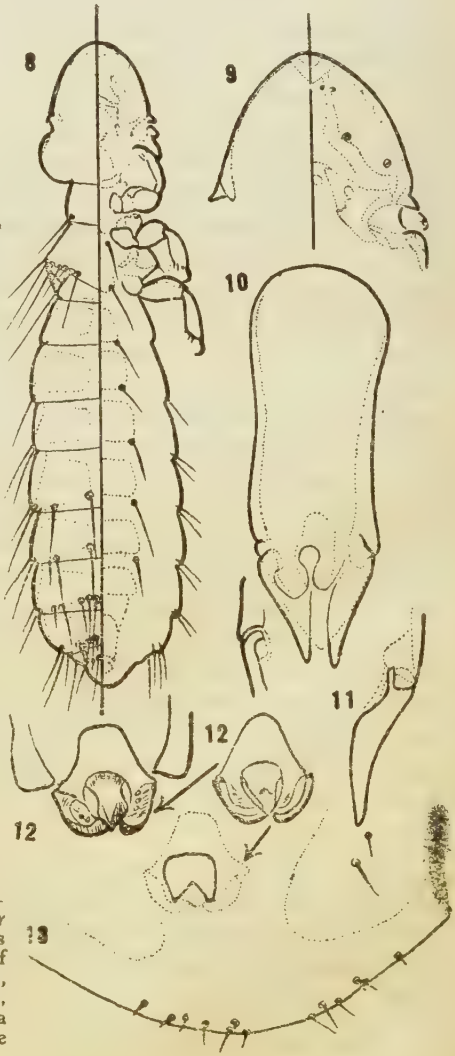
from Redwing, *Turdus musicus* Linn. These specimens were compared with the type (female in a rather poor condition). I have pointed out elsewhere that the females of the allied forms are usually similar in all details and therefore cannot be used for specific differentiation. In such cases it is only the males which are useful for specific diagnoses. These females were found identical with the females of *Bruelia iliaci* discussed above and therefore I consider *B. inornata* as a synonym of *B. iliaci*.

2. **Bruelia iliaci brevicolor** subsp. nov.

(Text-figs. 8-13)

TYPE-HOST : *Turdus migratorius propinquus.*

MALE : 1.72 x 0.39 mm. Head 0.39 x 0.33 mm., cephalic index 1 : 0.85. Preantennal region 0.21 x 0.26 mm. (index 1 : 1.24). Hind head 0.18 x 0.33 mm. (index 1 : 1.83). Prothorax 0.10 x 0.19 mm. Pterothorax 0.16 x 0.30 mm. (a little less than twice as broad as long). Abdomen 1.07 x 0.39 mm. Tergites V and VIII with one, VI-VII with two tergo-lateral setae on each side, V and VI with three and VIII with five tergo-central setae. Tergite IX with 1+2+1 setae on each side. Genital armature of the pattern shown in the figure and resembling *B. iliaci* in important details, 0.0188 mm. long. Basal plate 0.0135 mm. long, anterior width 0.0063 mm., and posterior width 0.0058 mm. Parameres 0.0053 mm. long. Mesosome 0.0030 x 0.0035 mm. (about 16 percent wider than long).



Text-figs. 8-13. *Bruelia iliaci brevicolor* subsp. nov. : (8) dorsal and ventral aspects of male, (9) dorsal and ventral aspects of the preantennal region showing the carinae, (10) male genital armature, (11) paramere, (12) various aspects of mesosome, (13) a portion of the subgenital plate of female showing the marginal chaetotaxy.

FEMALE : Similar to male ; difference, however, exists in abdominal chaetotaxy. 2.04 x 0.47 mm. Head 0.43 x 0.36 mm., cephalic index 1 : 0.83. Preantennal region 0.23 x 0.30 mm. (index 1 : 1.30). Hind-head 0.20 x 0.36 mm. (index 1 : 1.80). Prothorax 0.14 x 0.20 mm. Pterothorax 0.17 x 0.33 mm. Abdomen 1.30 x 0.47 mm. Tergites IV-IX with one seta on each side. Last segment with 2+2+2+2 setae. Vulvar plate as in *B. iliaci* with 7-8 marginal setae.

MATERIAL EXAMINED : 32 females and 4 males from *Turdus migratorius propinquus* (Arizona, March 1939 : Meinertzhagen Collection No. 13127). HOLOTYPE (male), ALLOTYPE (female) and PARATYPES (3 males and 31 females) from *Turdus migratorius propinquus*.

REMARKS : Kellogg (1906) recorded *Bruelia vulgata* from eight birds (Hopkins & Clay, 1952). The type-host of this species has not so far been fixed. One of the hosts in the list given by Hopkins & Clay (1952) is *Turdus migratorius migratorius* Linn. The author has 4 females and 32 females from *Turdus migratorius propinquus* before him but is unable to separate these specimens from *B. iliaci* (Denny). These specimens show differences of subspecific value in the abdominal chaetotaxy and male genitalia.

3. **Bruelia iliaci indiensis** subsp. nov.

(Text-figs. 14-19)

TYPE-HOST : *Turdus ruficollis atrogularis*.

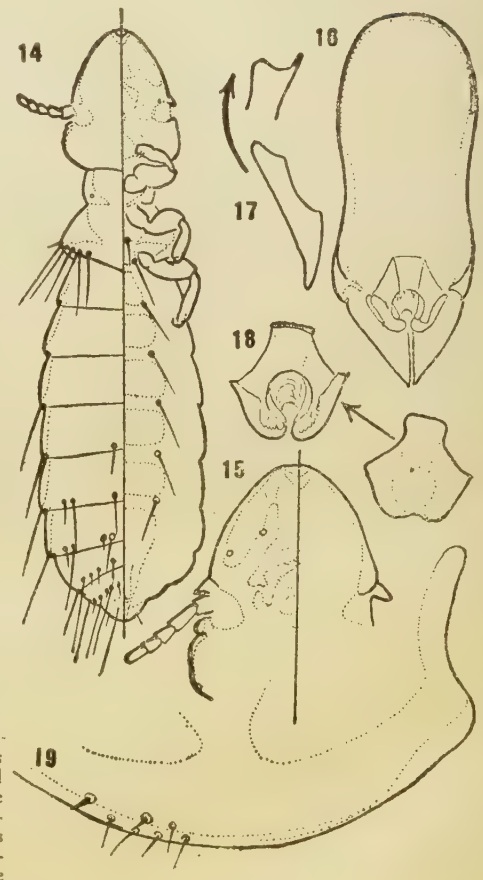
MALE : 1.57 x 0.45 mm. Head 0.39 x 0.31 mm., cephalic index 1 : 0.79. Preantennal region 0.20 x 0.25 mm. (index 1 : 1.25). Hind-head 0.19 x 0.31 mm. (index 1 : 1.63). Prothorax 0.09 x 0.20 mm. Pterothorax 0.13 x 0.29 mm. (more or less twice as broad as long). Abdomen 0.96 x 0.45 mm. Tergites V-VII with one tergo-central seta on each side. VI-IX with two tergo-lateral setae ; IX with four tergo-central setae. Sternal chaetotaxy as in *B. iliaci*. Genital armature 0.0169 mm. long. Basal plate 0.0118 mm. long, anterior and posterior widths 0.0060 mm. (more or less twice as long as broad, in *B. iliaci brevicolor* it is 2.5 times). Parameres 0.0051 mm. long, proximal heads simple but slightly differently modified, sharply pointed posterior portion of the parameres considerably shorter than the anterior portion as against almost equal in the above species. Mesosome 0.0035 x 0.0037 mm. (almost as wide as long), whereas in *B. iliaci* it is 30 percent wider than long.

FEMALE : 1.86 x 0.46 mm. Head 0.39 x 0.34 mm., cephalic index 1 : 0.87. Preantennal region 0.21 x 0.27 mm. (index 1 : 1.28). Hind-head

0.18 x 0.34 mm. (index 1 : 1.88). Prothorax 0.10 x 0.21 mm. Pterothorax 0.15 x 0.31 mm. Abdomen 1.21 x 0.46 mm. Chaetotaxy as in the above species. Subgenital plate narrow posteriorly.

MATERIAL EXAMINED : 3 males and 16 females from *Turdus ruficollis atrogularis* Temminck (United Provinces, India, 1939 in Meinertzhagen Collection No. 13358). HOLOTYPE (male) ALLOTYPE (female) and PARATYPE (2 males and 15 females) from *Turdus ruficollis atrogularis* Temminck in Meinertzhagen Collection No. 13358.

REMARKS : These specimens closely resemble *B. iliaci* (Denny). The male genitalia and female subgenital plate, however show differences in the two collections, warranting the present specimens to be given the status of a subspecies.



Text-figs. 14-19. *Bruelia iliaci indiensis* subsp. nov. : (14) dorsal and ventral aspects of male (15) a portion of the head showing carinae, (16) male genitalia, (17) paramere, (18) various aspects of mesosome, (19) a portion of the subgenital plate of female showing the marginal chaetotaxy.

4. **Bruelia stresemanni** (Clay)

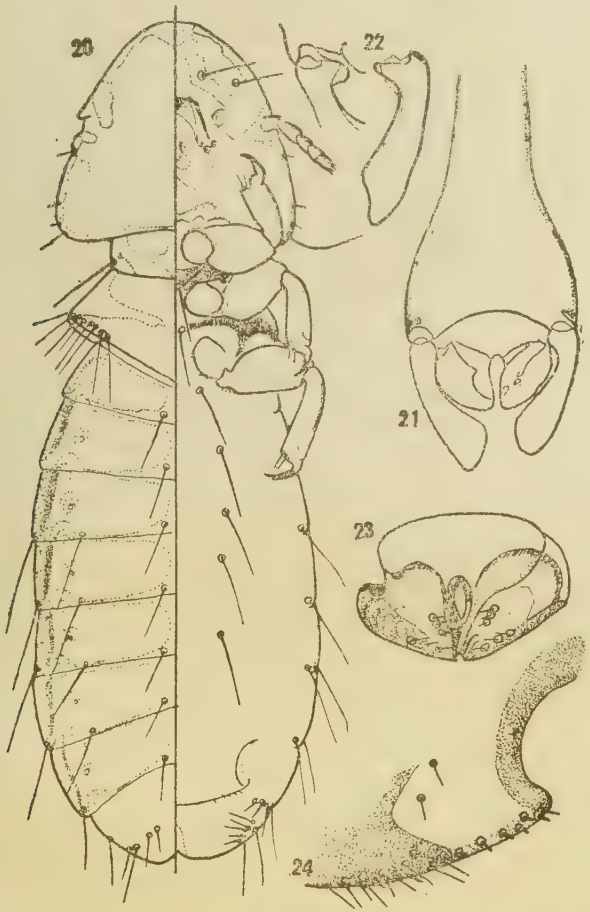
(Text-figs. 20-24)

Degeeriella stresemanni Clay, 1936 *Proc. zool. Soc. Lond.*, 1935, p. 910, figs. 6, 7b, pl. 2 fig. 3.

TYPE-HOST : *Zoothera monticola monticola* Vigors.

MALE : Well built, moderately sclerotized body. Head 0.55 x 0.67 mm., cephalic index 1 : 1.22. Preantennal region 0.25 x 0.47 mm. (index 1 : 1.88). Hind-head 0.30 x 0.67 mm. (index 1 : 2.23). Head parabolic in front, marginal carina interrupted anteriorly in the middle. Lateral interruptions incomplete and feeble and often inconspicuous. Dorsal suture

obliterated and leaves the anterior plate continuous with the dorsal



Text-figs. 20-24. *Bruelia stresemanni* (Clay) : (20) dorsal and ventral aspects of female, (21) male genital armature, (22) paramere, (23) mesosome, (24) a portion of the subgenital plate of female showing marginal chaetotaxy in the right half.

sclerotization of the head. Dorsal anterior plate of head shield-shaped with acute posterior angle. Ventral carina interrupted and fused to the end of the pre-marginal carina. Marginal carina well formed. Gular plate well formed with its anterior portion an equilateral triangle and its posterior portion more or less quadrangular.

Prothorax 0.15 x 0.36 mm., rectangular, with a long seta in the posterior lateral angle. Pterothorax 0.27 x 0.59 mm., five sided, lateral

sides considerably dilating, median posterior angle well marked, obtuse ; postero-lateral margin from outer end to the origin of abdominal margin with 6 long setae on each side. Ventrum with ovate plates furnished with two sternal setae.

Abdomen ovate, tergal plates II-VIII completely divided in the middle, each with a tergo-central seta. Pleural plates slender, proximal heads reaching as far as the stigmata of the adjacent segment. Abdominal sternites quadrangular, II-VI with a long and slender seta on each side. Terminal segments with a fused, narrow triangular plate. Genital armature as shown in the figure, of the pattern found in *B. zootherae*.

FEMALE : 2.35 x 0.85 mm., similar to male, slightly less robust than the male. Head 0.54 4 0.65 mm., cephalic index 1 : 1.20. Preantennal region 0.24 x 0.47 mm. (index 1 : 1.95) ; hind-head 0.30 x 0.65 mm. (index 1 : 2.17). Prothorax 0.14 x 0.34 mm. Pterothorax 0.23 x 0.59 mm. Abdomen 1.44 x 0.85 mm., widest at VI segment. Tergal plates II-VII completely divided in the middle, VIII incised or slightly notched in the middle. Abdominal chaetotaxy showing sexual variation ; II-VIII tergal plates with one moderately long tergo-central seta on each side ; IV-VII with one tergo-lateral seta also, IX with two setae on each side. Sternal plates II-VI with two setae on each side (IV sometimes with one seta on each side). Subgenital plate squat, posterior angulation very blunt. Vulvar plate concave laterally and convex posteriorly, of the shape of Indian 'ladies fan' with 14 very thick and 8-9 moderately short and slender setae.

MATERIAL EXAMINED : 2 males, 2 females from *Zoothera monticola monticola* Vigors (Sikkim, November 1900, Meinertzhagen Collection No. 3114 : PARATYPES).

REMARKS : These specimens resemble *B. zootherae* (Clay), *B. daumae* (Clay) and *B. merulensis* (Denny) in male genital armature. They, however, differ considerably in the shape of the head and details of the genital armature.

5. **Bruelia zootherae** (Clay)

(Text-figs. 25-29)

Degeeriella zootherae Clay, 1938, *Proc. zool. Soc. Lond.*, 1935, p. 909, figs. 4, 7a, pl. 2, fig. 1.

TYPE-HOST : *Zoothera marginata parva* Delacour

MALE : 2.17 x 0.76 mm., well built and heavily sclerotized. Head 0.51 x 0.58 mm., cephalic index 1 : 1.13, parabolically rounded in front. Marginal carina interrupted anteriorly in the middle and there is also a

well-defined lateral interruption. The dorsal suture does not pass across the head, and leaves anterior plate continuous with the dorsal sclerotization of the head. Dorsal anterior plate shield-shaped, with acute posterior angle. Ventral carina interrupted and fused to the ends of the proximal carina. Marginal temporal carina well formed. Preantennal region 0.24 x

Text-figs. 25-29. *Bruelia zootherae* (Clay) : (25) dorsal and ventral aspects of male, (26) male genitalia, (27) various aspects of parameres, (28) various aspects of mesosome, (29) a portion of the subgenital plate of female showing marginal chaetotaxy.

0.43 mm. (index 1 : 1.79). Hind-head 0.27 x 0.58 mm. (index 1 : 2.14).

Prothorax 0.13 x 0.33 mm. Pterothorax 0.23 x 0.53 mm., of the shape shown in *B. stresemanni*. Posterior margin with 8 long setae on each side, confined to the area between postero-lateral angle and point of origin of the abdominal segment.

Abdomen 1.30 x 0.76 mm., widest at the V segment. Tergal plates II-VIII interrupted in the middle, each with a tergo-central seta, IV-VII with a tergo-lateral seta, IX with 6-7 and the last with one seta. Pleural plates slender, of moderate length. Abdominal sternites II-VI quadrangular, each with a long and slender lateral seta.

Genitalia 0.0283 mm. long. Basal plate 0.0202 mm. long, anterior and posterior widths 0.0088 mm. Parameres 0.0072 mm. long, unlike other species of *Bruelia*, of the shape of a 'kukri' with typical hilt, outer margin regularly curved inwards from the extreme tips while the inner side is concave to some distance and then extends downwards to the extreme tip and forms more or less a spatulate blade. Mesosome 0.0051 x 0 0060 mm., ovate, with a fairly well defined central apophysis, reinforced with sclerotized longitudinal lobes.

FEMALE : Similar to male, 2.60 x 0.84 mm. Head 0.56 x 0.64 mm., cephalic index 1 : 1.14. Preantennal region 0.27 x 0.47 mm. (index 1 : 1.74). Hind-head 0.29 x 0.64 mm. (index 1 : 2.21). Prothorax 0.14 x 0.37 mm. Pterothorax 0.24 x 0.59 mm. Abdomen 1.66 x 0.84 mm. Abdominal chaetotaxy more or less as in *B. stresemanni* ; IX tergite with 3 setae ; II sternite with two, and III-VI with one seta on each side ; IV-V pleurites with one, VI-VII with two, VIII with four and IX with 6-8 setae. Vulvar plate with 17-23 setae as shown in the figure. Tip of the subgenital plate as shown in the figure.

MATERIAL EXAMINED : 2 males (Sikkim, January 1926, PARATYPES in Meinertzhagen Collection No. 3540), one male and three females (Annam, January 1907, PARATYPES Meinertzhagen Collection No. 3113, one male and one female (Kangpokpi, Manipur, January 26, 1952, in Meinertzhagen Collection No. 9865). All from *Zoothera marginata parva* Delacour.

REMARKS : These specimens resemble *B. stresemanni* (Clay), *B. daumae* (Clay) and *B. merulensis* (Denny). These allied forms can be easily distinguished from each other by the shape of the head in the clypeal region, and some modifications in the male genitalia.

6. **Bruelia daumae** (Clay)

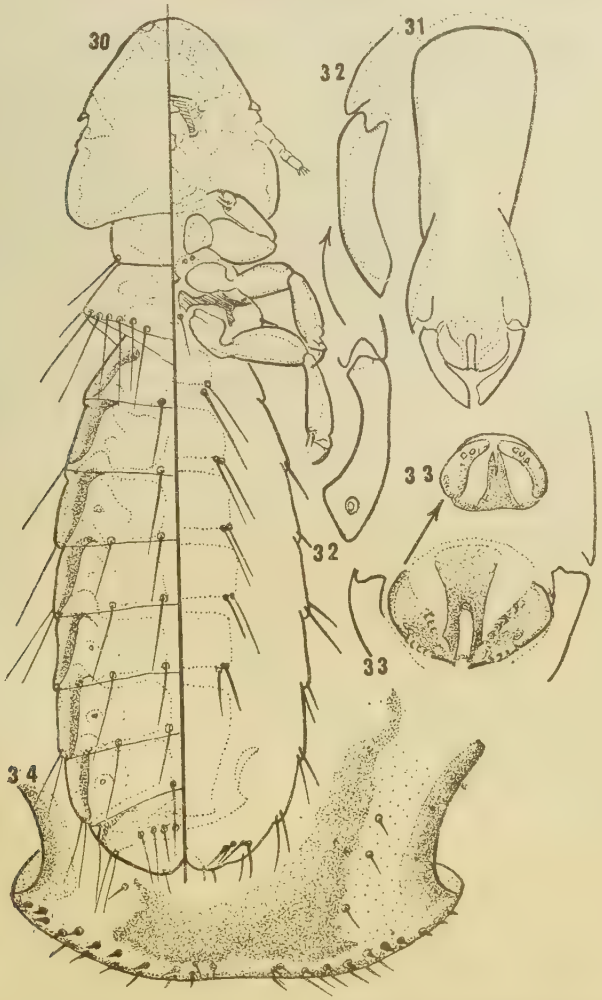
(Text-figs. 30-34)

Degeeriella daumae Clay, 1936, *Proc. zool. Soc. Lond.*, 1935, p. 910, figs. 5, 7c, pl. 2, fig 2.

TYPE-HOST : *Turdus dauma dauma* Latham.

MALE : 2.11 x 0.68 mm. Head 0.46 x 0.54 mm., cephalic index 1 : 1.18. Preantennal region 0.25 x 0.38 mm. (index 1 : 1. 52), parabolic in front, marginal carina always interrupted in front and laterally. The

lateral interruption is typical and oblique. Dorsal suture well-marked. Dorsal anterior plate with slightly concave anterior margin, posterior



Text-figs. 30-34. *Bruelia daumae* (Clay) : (30) dorsal and ventral aspects of female, (31) male genital armature, (32) various aspects of paramere, (33) various aspects of mesosome, (34) a portion of the subgenital plate of female showing marginal chaetotaxy.

point not well marked. Ventral carina interrupted as in other allied species, well sclerotized in the proximal region only. Temples as shown in the figures. Marginal temporal carina comparatively well-formed, broad.

Gular plate well-developed, its anterior portion an equilateral triangle and its posterior portion roughly quadrangular, longer than broad. Hind-head 0.21 x 0.54 mm. (index 1 : 2.57).

Prothorax 0.13 x 0.28 mm., latero-posterior angle with a long seta. Pterothorax 0.20 x 0.47 mm., median posterior angle of pterothorax obtuse, latero-posterior angle with one very small and one long seta followed by seven long (sub-equal) setae on each side. Pterothoracic sternites well-formed, with a single small antero-lateral seta and a similar lateral seta.

Abdomen 1.32 x 0.68 mm., widest at the IV-V segments. Abdominal tergites II-VIII separated widely in the middle line, IX with approximate tergites, X-XI entire. First tergite with a single tergo-central seta on each side. A single slender and moderately long tergo-lateral seta on segment IV-VII. The number of setae on the VIII segment varies from 8-10 on each side. Paratergal plates only slightly oblique to the long axis of the abdomen, narrow with elongate re-entrant heads but without inwardly directed processes. Pleural plates slender and of moderate length, II-III bare, IV-V with one, VI-VII with two, VIII with three, IX with two and X-XI with 6-8 setae. Sternite II roughly bell-shaped and bearing on each side a single seta, sternite III-VII quadrangular, each bearing a single seta on each side. Subgenital plate with anterior margin straight, steadily narrowing posteriorly to terminate in a blunt posterior apex. The ventral posterior margin of the abdomen may have a rounded or flattened appearance.

Genital armature 0.0291 mm. long. Basal plate 0.0246 mm. long, anterior width and posterior width 0.0100 mm., slightly concave in the middle. Parameres 0.0069 mm. long, of uniform thickness throughout, with a slightly inward curve, shaped like a 'kukri' as in the above species. Proximal heads simple. Mesosome 0.0044 x 0.0046 mm., of the pattern seen in *B. zootherae* (Clay).

FEMALE : 2.43 x 0.73 mm., similar to male. Head 0.54 x 0.58 mm., cephalic index 1 : 1.07. Preantennal region 0.26 x 0.45 mm. (index 1 : 1.73). Hind-head 0.28 x 0.58 mm. (index 1 : 2.08). Prothorax 0.14 x 0.35 mm. Pterothorax 0.25 x 0.50 mm. Abdomen 1.50 x 0.73 mm., tergites II-VIII completely divided in the middle, tergite IX entire. Terminal segment bilobed, with smoothly rounded apex and divided by a shallow sulcus. Tergites II-VIII, with a single moderately long tergo-lateral seta on each side. Tergite IX with four very stout marginal setae. Pleural plates with well developed heads. Subgenital plate more or less trapezoidal in outline. Vulvar plate with slight concavity in the middle, furnished with 11 heavy and 7 short marginal setae.

MATERIAL EXAMINED : 2 males (Burma, March 1902 : PARATYPES, in

Meinertzhagen Collection No. 3544) from *Turdus dauma aureus* and one female (Kohima (Assam), January 28, 1952 : in Meinertzhagen Collection, No. 19880) from *Turdus d.dauma* Latham.

REMARKS : This species resembles *B. merulensis* (Denny), *B. stresemanni* (Clay) and and *B. zootherae* (Clay) from which it can be differentiated only by the shape of the head in the preantennal region. The male genitalia also show some modifications.

7. **Bruelia merulensis** (Denny)

(Text-figs. 35-42)

Nirmus merulensis Denny, 1842, *Mon. Anopl. Brit.*, p. 51, 128, pl. 7, fig. 1.

TYPE-HOST : *Turdus merula merula* Linn.

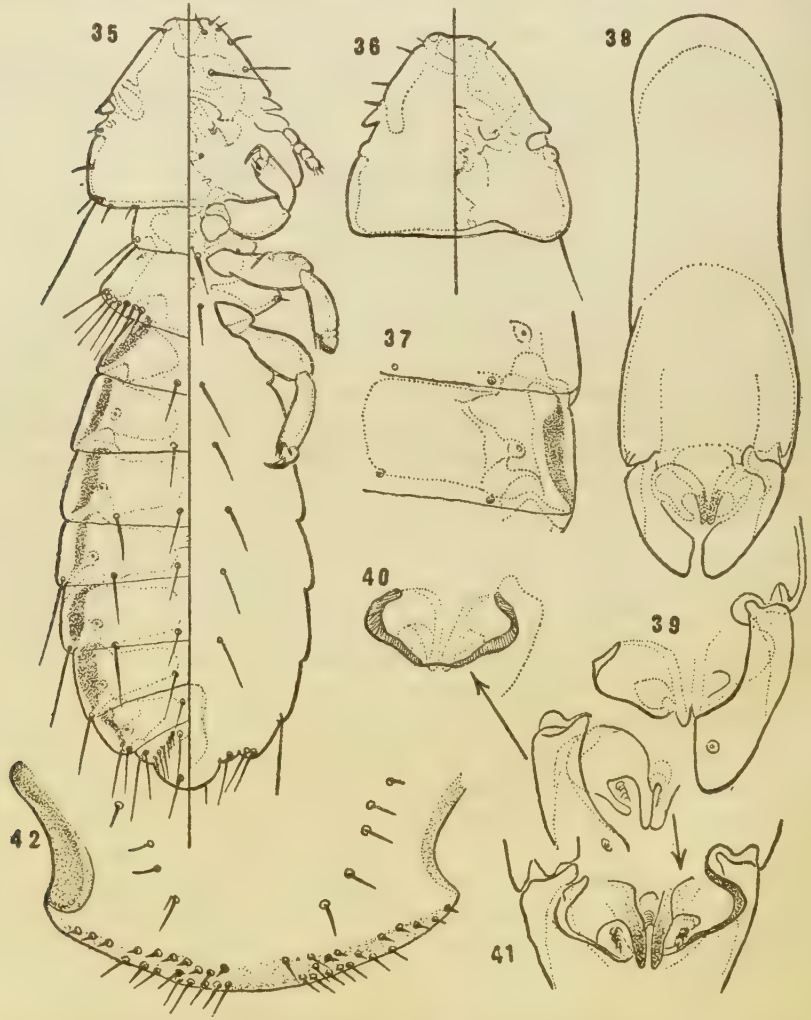
MALE : 2.25 x 0.70 mm., well built and fairly sclerotized. Head 0.54 x 0.59 mm., cephalic index 1 : 1. 09. Marginal carina interrupted in front and laterally. Dorsal clypeal signature square, shield-like. Ventral carina also interrupted, anterior ridge running as far as the tip, well formed. Temporal carina well built. Preantennal region 0.25 x 0.43 mm. (index 1 : 1.72). Hind-head 0.29 x 0.59 mm. (index 1 : 2.03).

Prothorax wider than long, sides convex with a hair in the latero-posterior angle, arising from near the spiracle. Lateral sclerite heavily pigmented, thickened, well developed, 0.18 x 0.34 mm. Pterothorax 0.25 x 0.51 mm., more or less trapezoidal in shape, moderately angulate posteriorly. Posterior margin, from outer end to the point of origin of the abdominal segment, with 7-8 moderately long setae on each side.

Abdomen 1.28 x 0.70 mm., widest at the V-VI segments, sides very convex, abruptly sloping down, beyond the VIII segment. Tergal plates II-IX interrupted in the middle. Paratergal plates comparatively heavily pigmented. Pleural plates rod-like. Tergal plates II-IX on each side, with a single tergo-central seta. A single slender and moderately long tergo-lateral seta on segments IV-VI ; segment IX with 7 unequal setae. Pleural setae moderately long ; segment II-III bare, others with 2-3 setae. Sternites I-VII with a single seta on each side. Posterior margin of the abdomen round.

Genitalia 0.0246 mm. long. Basal plate elongate, 0.0197 mm. long, anterior width 0.0069 mm., and posterior width 0.0081 mm., may be flattened or rounded anteriorly, sides subparallel. Parameres 0.0058 mm. long, short and stout, thickness uniform throughout. Proximal heads as shown in the figure. Mesosome 0.0039 x 0.0058 mm., squat, terminating at about two-thirds the length of the parameres, with a highly sclerotized central apophysis.

FEMALE : Similar to the male, 2.50 x 0 78 mm. Head 0.56 x 0.63 mm., cephalic index 1 : 1.12. Preantennal region 0.27 x 0.46 mm., (index 1 : 1.70). Hind-head 0.29 x 0.63 mm. (index 1 : 2.17). Prothorax 0.15 x 0.36



Text-figs. 35-42. *Bruelia merulensis* (Denny) : (35) dorsal and ventral aspects of male, (36) dorsal and ventral aspects of the head showing carinae, (37) a portion of the abdomen showing tergal plate, (38) male genital armature, (39) paramere, (40) various aspects of mesosome, (41) mesosome, (42) a portion of the subgenital plate of female showing marginal chaetotaxy.

mm. Pterothorax 0.25 x 0.54 mm. Abdomen 1.54 x 0.78 mm. Tergal plates IX-X entire, others interrupted in the middle. Chaetotaxy of the tergites

II-VII as in male, VIII-IX with one small seta on each side. Sternites I-VII with two setae on each side. Posterior segment with several setae round the divided shallow sulcus (1+3, 0+1, 1+1, 0+2). Subgenital plate well developed, vulvar plate with 8-9+12 setae on each side.

MATERIAL EXAMINED : 3 males (Kent, February 1937, Meinertzhagen Collection No. 8353), one male and 2 females (Pembrokeshire, April 20, 1939, B. M. 1939, No. 333), all from *Turdus merula merula*.

One male and three females from *Turdus merula syriacus* (Palestine, April 1953, Meinertzhagen 1953 Collection No. 225) were also not distinguishable from *Bruelia merulensis* (Denny).

REMARKS : These specimens resemble *B. stresemanni* (Clay) and allied species in male genitalia. The shape of the head, and the details of parameres and mesosome will, however, separate all these forms from each other easily.

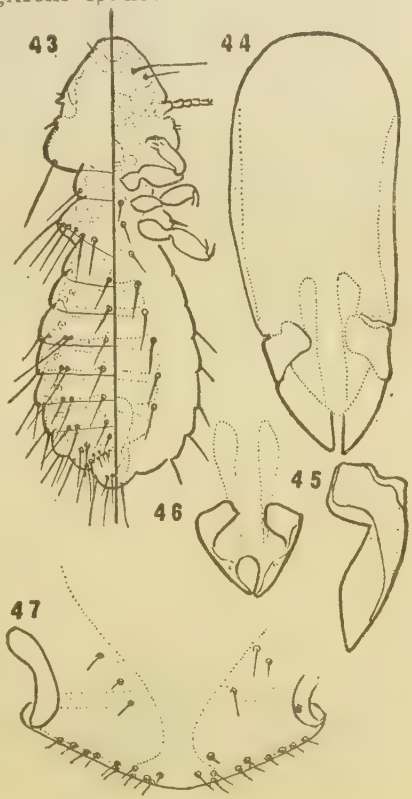
8. **Bruelia longifrons** sp. nov.

(Text-figs. 43-47)

TYPE HOST : *Hylocichla ustulata*.

MALE : 1.29 x 0.46 mm. Head 0.37 x 0.37 mm., cephalic index 1 : 1.00, approaching conical form. Preantennal region 0.17 x 0.28 mm. (index 1 : 1.65), clypeal region more or less flat in front and almost straight laterally. Marginal carina interrupted in front and laterally. Clypeal signature well formed, rectangular. Ventral carina as in other species. Hindhead 0.20 x 0.37 mm. (index 1 : 1.85). Temples as shown in the figure, moderately dilating. Gular plate well developed.

Prothorax 0.08 x 0.21 mm., with one elongate hair in the latero-



Text-figs. 43-48. *Bruelia longifrons* sp. nov. (43) dorsal and ventral aspects of male, (44) male genital armature, (45) paramere, (46) mesosome, (47) a portion of subgenital plate of female showing marginal chaetotaxy.

posterior angle. Pterothorax 0.13 x 0.34 mm., median posterior angle well marked, latero-posterior angle with one small and one long seta followed by five long setae on each side. Pterothoracic sternites well formed, with a single, small anterior seta and a small lateral seta.

Abdomen 0.71 x 0.46 mm., tergites II-VIII with one tergo-central seta, tergite IX with 6 small and irregularly beset small setae. Tergites IV-VIII with two subequal tergo-lateral setae, IX with one tergo-lateral seta, X+XI with 3 setae. Paratergal plates comparatively heavily sclerotized. Pleural plates rod-like, pleural setae moderately long, II-III bare, IV-IX with 2-4 setae ; segments X+XI fused to form a rounded lobe.

Genitalia 0.0192 mm. long. Basal plate 0.0131 mm. long, anterior width 0.0075 mm. and posterior width 0.0061 mm., sides straight. Parameres 0.0071 mm. long, unlike other species, shorter and broader, widest in the middle, of the shape of 'share of a furrow-turning plough'. Proximal head well developed, flattened, hilt of the shape of the blade of a golf stick. Mesosome 0.0061 mm. long, acutely angulate posteriorly with a central apophysis reinforced with spindle-shaped lateral sclerotization.

FEMALE : 1.72 x 0.55 mm., similar to the male. It resembles the female of *b. antiqua* (given below). Head 0.39 x 0.42 mm., cephalic index 1 : 1.07. Preantennal region 0.18 x 0.33 mm. (index 1 : 1.83). Hind-head 0.21 x 0.42 mm. (index 1 : 2.00). Prothorax 0.10 x 0.25 mm. Pterothorax 0.16 x 0.37 mm. Abdomen 1.07 x 0.55 mm. It differs from the allied species in the shape of the subgenital plate, the posterior angle is considerably narrow, vulvar plate with 10-12 marginal setae.

MATERIAL EXAMINED : One male (HOLOTYPE), one female (ALLOTYPE) from the Olive-backed Thrush (*Hylocichla ustulata*). Arena, Wis., May 20, 1953 : W. S. Woodman Collection.

REMARKS : These specimens do not resemble any species so far described from the True Thrushes. The head in this form is narrow in front, of the pattern seen in *Bruelia myiophoneae* (Clay). This species differs from the allied forms in the considerably smaller size of the males and the structure of the male genital armature.

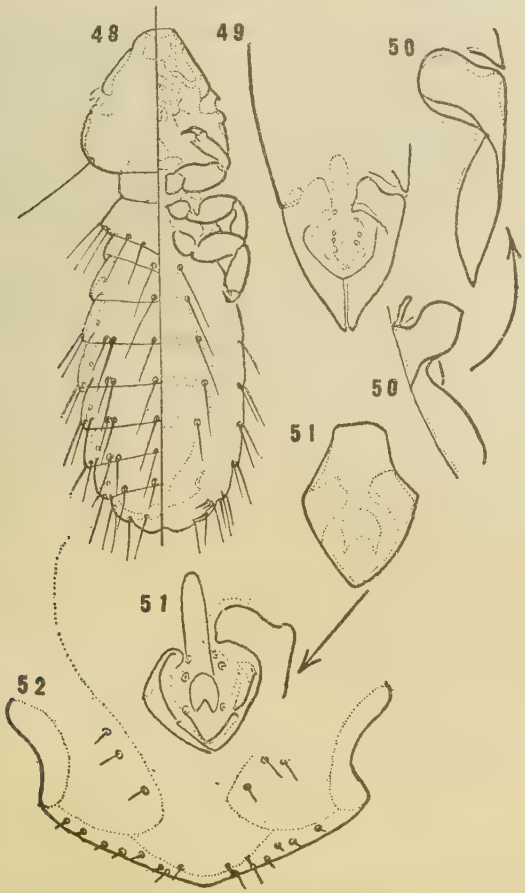
9. **Bruelia longifrons antiqua** subsp. nov.

(Text-figs. 48-52)

TYPE-HOST : The Hermit Thrush (*Hylocichla guttata*).

MALE : 1.23 x 0.41 mm. Head 0.36 x 0.37 mm., cephalic index 1 : 1.03. Preantennal region 0.17 x 0.20 mm. (index 1 : 1.71). Latero-clypeal region with slight concavity in the anterior half. Hind-head 0.19 x 0.37 mm. (index 1 : 1.95).

Prothorax 0.09 x 0 21 mm., latero-posterior angle with a single moderately long seta. Pterothorax 0.12 x 0.30 mm.



Text-figs. 48-52. *Bruelia longifrons antiqua* subsp. nov. (48) dorsal and ventral aspects of female, (49) male genital armature, (50) various aspects of parameres, (51) various aspects of mesosome, (52) a portion of the subgenital plate of female showing shape and marginal chaetotaxy.

Abdomen 0.66 x 0.41 mm., widest at the IV-V segments. Segment II very narrow, others of almost equal length, II-VIII and X+XI tergites with one tergo-central seta, IX with 6 tergo-central setae. Two subequal, moderately long tergo-lateral setae on IV-VII tergites. Tergal plates VIII and IX, each with one such seta. Pleural setae moderately long ; segment II bare ; III-IX segments with 2-4 setae. Posterior segment rounded.

Male genitalia not clearly visible. Parmeres 0.0075 mm. long. Mesosome 0.0075 mm. long, with two central spindle-shaped median sclerotizations. Basal plate 0.0061 mm. wide at the apex.

FEMALE : Similar to the male, 1.63 x 0.45 mm. Head 0.39 x 0.41 mm., cephalic index 1 : 1.05. Preantennal region 0.18 x 0.30 mm. (index 1 : 1.66). Hind-head 0.21 x 0.41 mm. (index 1 : 1.95). Prothorax 0.10 x 0.23 mm. Pterothorax 0.15 x 0.32 mm. Abdomen 0.99 x 0.45 mm. Chaetotaxy as in *B. myiophoneae* (Clay). Vulvar plate as shown in the figure, posterior angle of the subgenital plate considerably wide, cross-piece of the anchor with 7-8 small setae on each side. This character separates it from *Bruelia longifrons*.

MATERIAL EXAMINED : One male (HOLOTYPE), one female (ALLOTYPE) and one female (PARATYPE) from the Hermit Thrush (*Hylocichla guttata*), Vilas, Wis., May 7, 1952 in W. S. Woodman Collection.

REMARKS : This species resembles *Bruelia longifrons* (described above). The male available to me is teneral and it is difficult to see the character of genital armature clearly. The dorsal chaetotaxy and the subgenital plate in the female exhibit differences of subspecific standard. The form and the posterior angle of the subgenital plate do not seem to be of specific importance and therefore we are not inclined to raise its status beyond subspecific level.

10. Bruelia myiophoneae (Clay)

(Text-figs. 53-58).

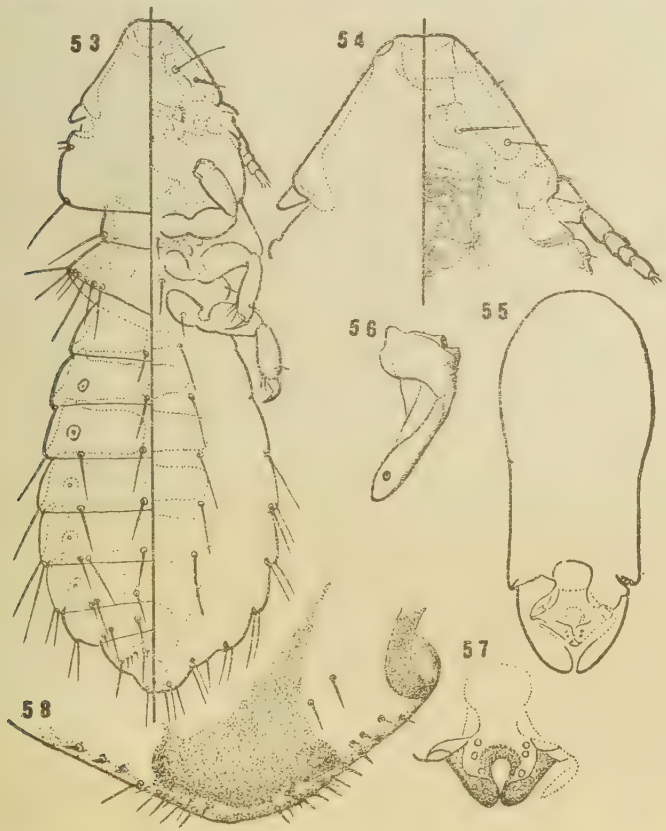
Degeeriella myiophoneae Clay, 1935, *Proc. zool. Soc. Lond.*, 1935, p. 911, fig. 7g, pl. 2 fig. 4.

TYPE-HOST : *Myiophoneus coeruleus temminckii* Vigors

MALE : 1.92 x 0.65 mm. Head 0.53 x 0.52 mm., cephalic index 1 : 0.98, narrow in front. Preantennal region 0.25 x 0.39 mm. (index 1 : 1.56). Marginal carina always interrupted in front and laterally. Dorsal suture well marked, anterior plate distinct, squarish, shield-like. Ventral carina interrupted as in other species, but sclerotized only proximally on each side. Hind-head 0.28 x 0.52 mm. (index 1 : 1.85). Temples slightly convex laterally, posterior angle rounded, marginal temporal carina well developed. Gular plate well formed.

Prothorax 0.12 x 0.28 mm., transverse, posterior angle with one long seta. Pterothorax 0.17 x 0.46 mm., lateral margin divergent, posterior angulation more or less obtuse. Latero-posterior angles with one very small and one long seta followed by a group of rather long setae on each side.

Abdomen 1.10 x 0.66 mm., ovate, widest at the IV-V segments. Segments IX and X are fused to form a pygidium and never separated from XI



Text-figs. 53-58. *Bruelia myiophoneae* (Clay) : (53) dorsal and ventral aspects of male, (54) dorsal and ventral aspects of preantennal region showing carinae, (55) male genital armature, (56) paramere, (57) mesosome, (58) a portion of the subgenital plate of female showing marginal chaetotaxy.

by a definite suture. Tergal plates II-VI medially interrupted, quadrate. Tergal plates VII and VIII not only separated but also greatly narrowed in the middle. Tergal plate IX runs across the segment and narrows in the middle ; II-III tergites with a single tergo-central seta ; IV-V with one tergo-central and one tergo-lateral seta ; VI-VIII with one tergo-central and 2 tergo-lateral setae, IX with 2+6 setae on each side ; X+XI with 3+2 setae on each side. Paratergal plates simple, with shallow re-entrant heads and devoid of any inwardly directed processes ; II-III bare ; IV-VI

and X+XI with 2, VII with 3, VIII with 4 moderately long setae. The sternal thickenings in the form of median plates, those of the posterior segments VII-XI fused to form an irregular conical plate. Sternites II-VI with one seta on each side, X+XI with one small seta.

Genitalia typical. Basal plate moderately long, about three times as long as parameres and more or less twice its width. Margins markedly sinuate, straight basally, concave in the middle and convex distally. Parameres rather typical, tapering very slightly and gradually, extreme tips blunt. Proximal heads of the parameres rather strongly developed. Mesosome shield-shaped, with postero-lateral portion well sclerotized, of the pattern shown in the figure.

FEMALE : Slightly stouter than the male, 2.27 x 0.76 mm. Head 0.57 x 0.58 mm., cephalic index 1 : 1.02. Preantennal region 0.27 x 0.44 (index 1 : 1.62). Hind-head 0.30 x 0.58 mm. (index 1 : 1.93). Prothorax 0.14 x 0.28 mm. Pterothorax 0.20 x 0.50 mm. Abdomen 1.36 x 0.76 mm., widest at the IV-V segments. Tergal plates II-VII with one tergo-central seta on each side ; IV-VIII with one such seta on each side ; IX with three setae. Sternal plates II-VI with one seta on each side. Pleurites II-III bare : IV-VI with two setae ; VII with three, VIII with four and IX with 8 setae. Subgenital plate well developed, apically broader. Vulvar plate with 14 setae, arranged in two asymmetrical rows.

MATERIAL EXAMINED : One male (PARATYPE) from Baltistan (India), one male (PARATYPE ; Kashmir, March 1925 in Meinertzhagen Collection No. 3541), 4 females and one male from Afghanistan (Meinertzhagen, April 1937 : 9749), two males and three females (Ansari, June 1940, August 1942, from Kulu). All from the Whistling Thrush (*Myiophoneus coeruleus temminckii* Vigors.)

REMARKS : This species resembles *B. longifrons* in the shape of the head, but differs in being more robust and in the male genitalia.

11. **Bruelia turdinulae** sp. nov.

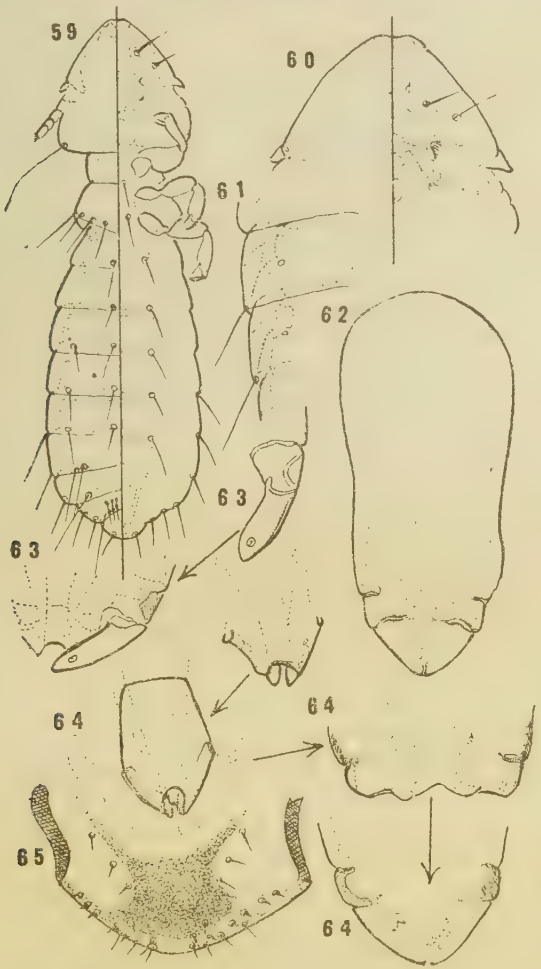
(Text-figs. 59-65)

TYPE-HOST : *Turdus philomelos philomelos.*

MALE : 1.23 x 0.44 mm. Head 0.37 x 0.38 mm., cephalic index 1 : 1.03. Preantennal region 0.18 x 0.32 mm. (index 1 : 1.78). Hind-head 0.19 x 0.38 mm. (index 1 : 2.00). Marginal carina as in others, lateral interruption incomplete. Anterior plate not well pigmented. Dorsal suture not passing across the head and leaves the posterior part of the anterior plate continuous with the dorsal sclerotization of the head.

Prothorax 0.10 x 0.24 mm., with a long seta in the posterior lateral

angle. Pterothorax 0.15 x 0.34 mm., condsiderably dilated laterally, posterior margin with 6 long setae on each side, median bare.



Text-figs. 59-65. *Bruelia turdinulae* sp. nov. (59) dorsal and ventral aspects of male, (60) dorsal and ventral aspects of a portion of head showing carinae, (61) a portion of the abdomen showing tergal plates, (62) male genital armature, (63) various aspects of paramere, (64) various aspects of mesosome, (65) a portion of the subgenital plate of female showing form and marginal setae.

Abdomen 0.61 x 0.44 mm. Tergal plates II-VIII interrupted in the middle, IX entire ; II-VIII with one tergo-central seta ; IV-VI and VIII-IX with one tergo-lateral seta ; VII with two tergo-lateral setae on each side ;

IX with four tergo-central setae, and a row of 3+3 setae on the posterior segments. Sternites as in others. Pleurites II and III bare, IV-V with one, VI and X with two and VII-VIII with three moderately long setae.

Genitalia 0.0178 mm. long. Basal plate 0.0154 mm. long, anterior width 0.0091 mm. and distal width 0.0067 mm., slightly concave in the middle and rounded anteriorly. Parameres 0.0035 mm., of the shape shown in the figure (like blunt scalpel blade). Proximal head not well developed. Mesosome 0.0035 mm. long.

FEMALE : 1.70x0.44 mm. Head 0.40 x 0.41 mm., cephalic index 1: 1.02. Preantennal region 0.21 x 0.34 mm. (index 1 : 1.62). Hind-head 0.19 x 0.41 mm. (index 1 : 2.15). Prothorax 0.10 x 0.23 mm. Pterothorax 0.16 x 0.32 mm. Abdomen 1.04 x 0.44 mm. Tergal plates II-VIII with one tergo-central seta; IV-XI with one tergo-lateral seta and IX with two tergo-central setae on each side. Sternal plates as in male. Pleural plates II-III bare ; IV-V and X with one ; VI-VII with two, VIII with four and IX with seven setae. Subgenital plate as shown in the figure. Vulvar plate marginally beset with 9- 10 setae.

MATERIAL EXAMINED : HOLOTYPE (male), ALLOTYPE (female) and PARATYPES (3 males from Herts, North Mymms (D. Borton and F. F. Shillies, 2nd July 1933, B. M. 1936-624), from the Song Thrush (*Turdus philomelos philomelos*), 3 males from Cornwall (Meinertzhagen, January 1937, Collection No. 8229) from the Song Thrush (*T. p. philomelos*).

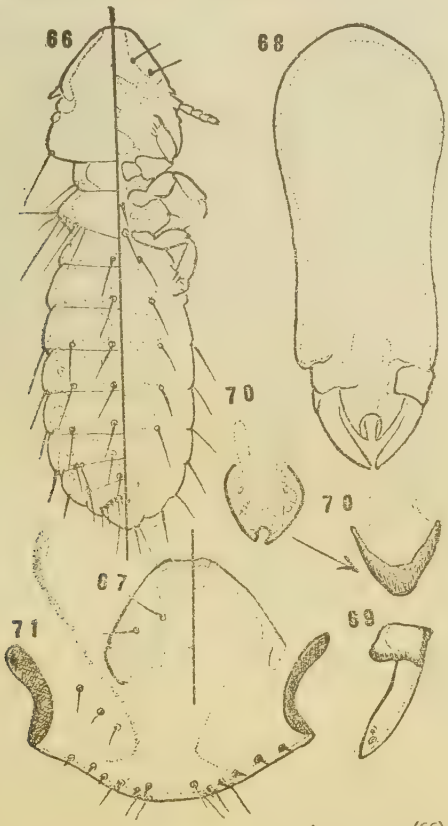
REMARKS : According to Miss T. Clay (Personal communication) there is some confusion about the name of the Song Thrush. The specialists in the British Museum (Natural History) have indentified this bird as *Turdus philomelos philomelos*. She has also very kindly sent me some slides where the Song Thrush is identified as *Turdus musicus musicus* Linn. In Meinertzhagen's Collection, *Turdus musicus musicus* is the Red Wing. I have compared the collection of *Bruelia* from the two lots and found that the collection from the Song Thrush resembles *Bruelia marginata* group in the body form and the general shape of the head, while the collection from the Red Wing (*Turdus musicus musicus*) is referable to *Bruelia iliaci*. The specimens from *Turdus philomelos philomelos* resemble *Bruelia marginata* and others of the group in body and general form of the head. These specimens resemble *Brulia eternitatus* and *B. ilmasae* in the abdominal chaetotaxy. It differs from all others but *Bruelia eternitatus* in the shape of the parameres and mesosome. From *Bruelia eternitatus* it differs in the details of the mesosome, proximal heads of the parameres and the subgenital plate of female.

12. **Bruelia turdinulae eternitatus** subsp. nov.

(Text-figs. 66-71)

TYPE-HOST : *Turdus philomelos clarki*

MALE : 1.41 x 0.48 mm. Head 0.36 x 0.36 mm., cephalic index 1 : 1.00. Preantennal region 0.18 x 0.29 mm., (index 1 : 1.61). Hind-head 0.18 x



Text-figs. 66-71. *Bruelia turdinulae eternitatus* subsp. nov. (66) dorsal and ventral aspects of male, (67) a portion of head showing carinae, (68) male genital armature, (69) paramere, (70) various aspects of mesosome, (71) a portion of the subgenital plate of female showing shape and marginal chaetotaxy.

0.36 mm., (index 1 : 2.00). Prothorax 0.09 x 0.21 mm. Pterothorax 0.14 x 0.32 mm. Abdomen 0.82 x 0.43 mm.

FEMALE : 1.75 x 0.53 mm. Head 0.40 x 0.39 mm., cephalic index 1 : 0.97. Preantennal region 0.21 x 0.30 mm., (index 1 : 1.43). Hind-head 0.19 x 0.39 mm. (index 1 : 2.05). Prothorax 0.09 x 0.23 mm. Pterothorax

0.17 x 0.35 mm. Abdomen 1.09 x 0. 53 mm.

MATERIAL EXAMINED : HOLOTYPE (male), ALLOTYPE (female) and PARATYPES (8 males and 6 females) from Kent (Meinertzhagen, February 1937, No. 8335). All from *Turdus philomelos clarki*.

REMARKS : The specimens from *T. philomelos clarki* resemble the above species in almost all the salient characters. Male genitalia and subgenital plate in female, however, exhibit some important differences which are presented in the table below. In the light of these differences I am inclined to assign these specimens the status of a subspecies.

Bruelia turdinulae from *Turdus philomelos philomelos*.	*Bruelia turdinulae eternitatus* from *Turdus philomelos clarki*.
Head : Dorsal anterior plate strongly concave anteriorly.	Dorsal anterior plate moderately concave in front.
Abdominal tergites : IX with 4 tergo-central setae, 3 small additional setae in the posterior row.	IX with 3 tergo-central setae on each side. Additional row of setae wanting.
Male genitalia : 0.0173 mm. long, comparatively squat (100 : 117).	0.0204 mm. long, comparatively long and narrow. (100 : 83.3)
Basal plate : 0.0154 mm. l o n g, posterior width 0.0091 mm., distal width 0.007 mm.	0.0157 mm. long, posterior width 0.0092 mm., distal w i d t h 0.0064 mm.
Parameres : 0.0035 mm. long, blunt, proximal heads not well developed (100 : 157)	0.0055 mm. long, narrow with very well developed proximal heads (100 : 77.7).
Mesosome : 0.035 mm. long, "V-shaped" sclerotization wanting. (100 : 128.5).	0.0045 mm. l o n g, "V-shaped" sclerotization present in one view. (100 : 77.7).
Female subgenital plate : Squat and comparatively broad distally. Vulvar plate a round arch. With 9-10 marginal setae.	Subgenital plate narrow distally, vulvar plate like a flattened arch. With 9-9 marginal setae.

13. **Bruelia oudhensis** sp. nov.

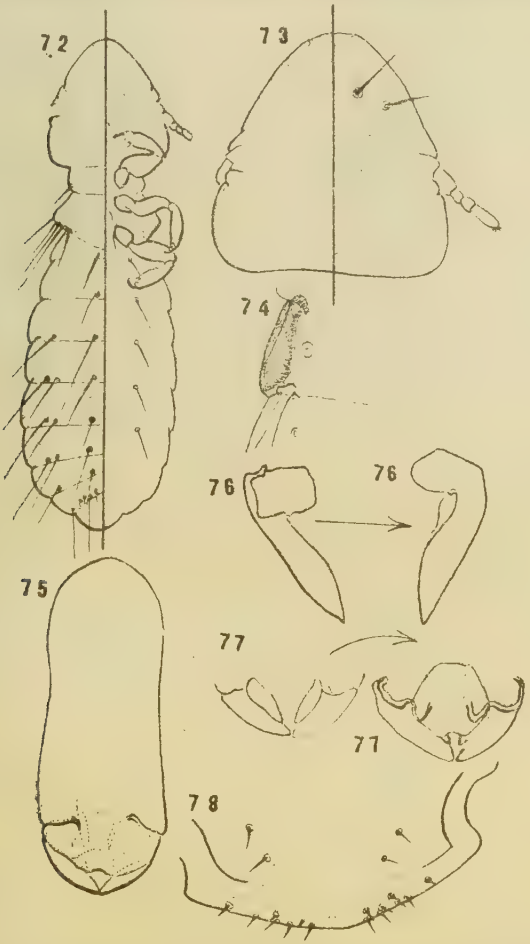
(Text-figs. 72-78)

TYPE-HOST : *Turdus merula nigropelios* Lafresnay.

MALE : 1.62 x 0.47 mm. Head 0.36 x 0.35 mm., cephalic index 1 : 0.97. Preantennal region 0.17 x 0.26 mm. (index 1 : 1.53). Marginal carina as

in other species, dorsal suture well marked but not passing across the head. Hind-head 0.19 x 0.35 mm. (index 1 : 1.84).

Prothorax 0.08 x 0.21, with a small seta in the postero-lateral angle.



Text-figs. 72-78. *Bruelia oudhensis* sp. nov. (72) dorsal and ventral aspects of male, (73) dorsal aspect of head showing carinae, (74) a portion of the abdomen showing tergal plate, (75) male genital armature, (76) parameres, (77) various aspects of mesosome, (78) a portion of the subgenital plate of the female showing marginal setae.

Pterothorax 0.14 x 0.31 mm. Posterior angulation very obtuse, latero-posterior angle with one small and one moderately long seta followed by 4-5 setae on each side.

Abdomen 1.04 x 0.47 mm. Tergal plates II-VIII with a single tergo-central seta, IV and VIII with one and V-VII with two tergo-lateral setae on each side, IX with 2 long and 3-4 small setae on each side. Last tergite with only one long seta on each side. Sternites as in other species. Pleurites II and III bare, IV-VI and IX+X with 2, VII with 3, and VIII with 3-4 setae.

Genitalia 0.0189 mm. long. Basal plate 0.0138 mm. long, anterior width 0.0058 mm., distal width 0.0051 mm., slightly concave in the anterior one third. Parameres 0.0043 mm. long, slender, of the shape of a knife blade. Mesosome 0.0035 mm. long, of the shape shown in the figure.

FEMALE : 1.46 x 0.52 mm. Head 0.39 x 0.38 mm., cephalic index 1 : 0.97. Preantennal region 0.20 x 0.30 mm. (index 1 : 1.50). Hind-head 0.19 x 0.38 mm. (index 1 : 2.00). Prothorax 0.09 x 0.23 mm. Pterothorax 0.16 x 0.35 mm. Abdomen 0.82 x 0.52 mm. Tergal chaetotaxy reduced, II-VII with one tergo-central seta, IV-IX with two tergo-lateral, IX with 2 tergo-lateral setae on each side. Vulvar plate of the shape shown in the figure. Vulvar plate with 8-9 setae disposed of as shown in the figure. Pleural plates II-III bare, IV with one, V-VII with two, VIII with three and IX with 7 setae.

MATERIAL EXAMINED : HOLOTYPE (male), ALLOTYPE (female) and PARATYPES (5 males and 7 females) from Bombay (Meinertzhagen; February 1927, slide No. 8472). All from *Turdus merula nigropelios* Lafresnay.

REMARKS : The specimens from *Turdus merula nigropelios* before me resemble *B. viscivori* and other allied forms in the general shape of the body and the abdominal chaetotaxy, but differ from all of these in the male genitalia. The parameres and mesosome in this species exhibit a different shape and modifications.

14. **Bruelia marginata** (Burmeister)

(Text-figs. 79-85)

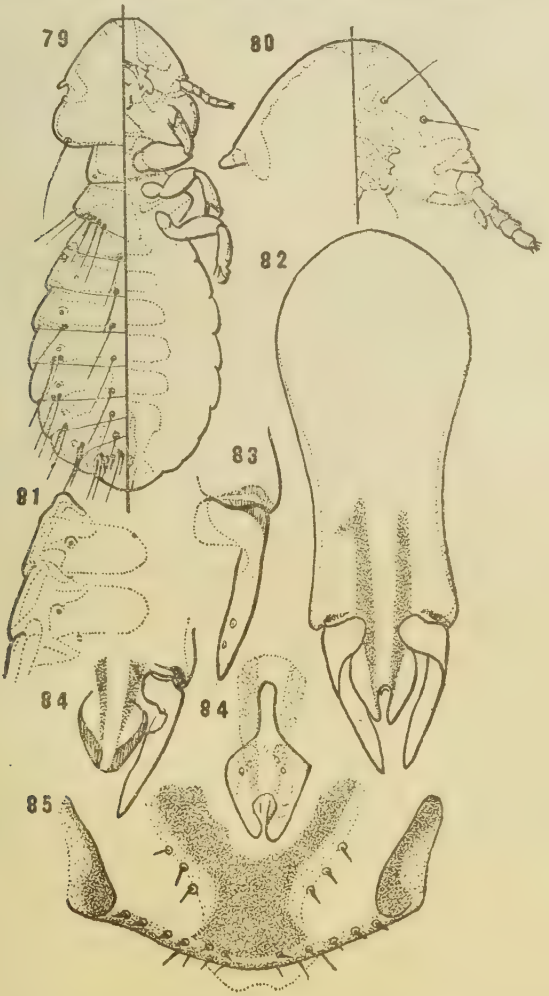
Nirmus marginata Burmeister, 1838, *Handb. Ent.*, 2, p. 431.

TYPE-HOST : *Turdus pilaris* Linn.

MALE : 1.33 x 0.52 mm. Head 0.35 x 0.36 mm., cephalic index 1 : 1.03. Marginal carina is interrupted medially and there is also an incomplete lateral interruption. The dorsal suture does not pass across the head and leaves the posterior part of the anterior plate continuous with the dorsal chitinization of the head. Gular plate well developed. Preantennal region 0.18 x 0.32 mm. (index 1 : 1.77). Hind-head 0.17 x 0.36 mm. (index 1 : 2.12).

Prothorax 0.09 x 0.21 mm., latero-posterior angle with one seta.

Pterothorax 0.14 x 0.33 mm., median posterior angle obtuse, latero-posterior angle with 2 long and a small seta on each side followed by 4 subequal



Text-figs. 79-85. *Bruelia marginata* (Burmeister): (79) dorsal and ventral aspects of male, (80) a portion of head (dorsal and ventral) showing carinae, (81) a portion of the abdomen showing tergal plates, (82) male genital armature, (83) paramere, (84) various aspects of mesosome, (85) a portion of the subgenital plate of the female showing marginal chaetotaxy.

hairs confined to the lateral half of the posterior margin. Thoracic sternites well developed, with a single lateral seta.

Abdomen 0.75 x 0.52 mm., widest at the IV segment. Tergites II and III with a single tergo-central seta on each side ; IV with one tergo-central and one tergo-lateral seta ; V-VIII with one tergo-central and two tergo-lateral setae ; IX with two tergo-lateral and 5 tergal setae on each side. Paratergites as shown in the figure. Pleural plates slender, moderately long ; II-III bare, IV with one, V, VII, IX and X with two, and VI, VIII with three subequal setae. Sternites II-VI with one long seta on each side.

Genitalia 0.0242 mm. long. Basal plate 0.0175 mm. long, wide (0.0087 mm.) and rounded anteriorly and narrow (0.0069 mm.) and concave distally. Parameres 0.0069 mm. long, of uniform thickness throughout, proximal heads as shown in the figure. Mesosome 0.0066 mm. long, well developed, with a fairly well developed central apophysis reinforced on both sides (visible in one aspect), resembling a scoop with a small handle.

FEMALE : 1.69 x 0.56 mm., similar to male. Head 0.39 x 0.41 mm., cephalic index 1 : 1.05. Preantennal region 0.20 x 0.34 mm. (index 1 : 1.70). Hind-head 0.19 x 0.41 mm. (index 1 : 2.15). Prothorax 0.09 x 0.23 mm. Pterothorax 0.16 x 0.36 mm. and abdomen 1.05 x 0.56 mm. Tergal plates approximate or widely separated. Tergites II-IX with one tergo-central seta on each side ; IV-IX with one tergo-lateral seta ; X with two small setae on each side. Sternal plates as in male. Subgenital plate well formed, posterior tip blunt as in the figure. Vulvar plate with 5-6 thick and 3-4 feeble setae on each side ; II and III pleurites bare, IV and V with one, VI with two, VII and VIII with three, IX with 3-6 setae.

MATERIAL EXAMINED : 6 males, 12 females from Heacham, Norfolk (Meinertzhagen, January 1941, Collection No. 14084), 4 males and 4 females from Uppsala, Sweden (Meinertzhagen, October 1946, Collection No.16097) and one male from Estonio (Meinertzhagen, October 1934, Collection No. 1932). All from the type-host (*Turdus pilaris pilaris* Linn.). I designate NEOTYPE (male from Uppsala, Sweden, October 1946), ALLOTYPE (female on the same slide 16097) and all others as NEOPARATYPES (10 males and 15 females).

REMARKS : These specimens resemble *B. viscivori* (Denny), *B. amsei* (Eichler), *B. oudhensis* sp. nov., *B. ilmasae* sp. nov., *B. turdinulae* sp. nov. and *B. turdinulae eternitatus* subsp. nov. in the shape of the head. The male genitalia are of the pattern found in *B. viscivori*, *B. amsel*, and *B. ilmasae*. The shape of the mesosome and the proximal head of the parameres will however separate these forms from each other easily.

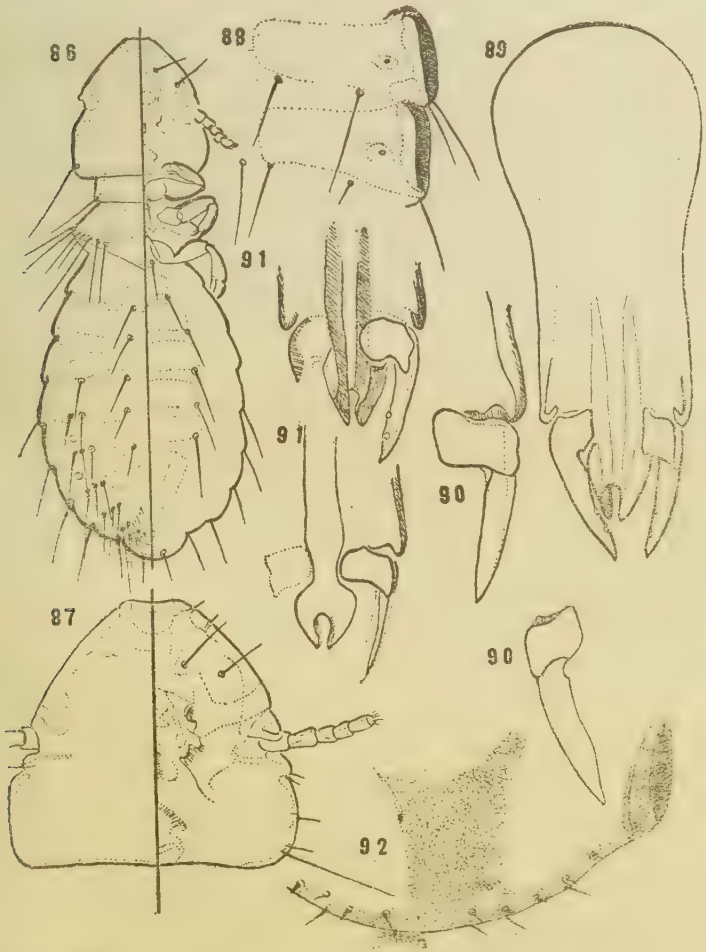
Hopkins & Clay (1952) have recognized *Nirmus marginalis* (Burmeister) as a synonym and I agree with them in this finding.

15. **Bruelia amsel** (Eichler)

(Text-figs. 86-92)

Allobruelia amsel Eichler, 1952, *Bedeuting der Vogelwelt* in *Forschung und Praxis*, p. 40, fig 37.

TYPE-HOST : *Turdus merula merula* Linn.



Text-figs. 86-92. *Bruelia amsel* (Eichler): (86) dorsal and ventral aspects of male, (87) dorsal and ventral aspects of head showing carinae, (88) a portion of the abdomen showing tergal plate, (89) male genital armature, (90) parameres, (91) mesosome, (92) a portion of the subgenital plate of female showing the marginal setae.

MALE : 1.51 x 0.59 mm. Head 0.38 x 0.40 mm., cephalic index 1 : 1.05. Preantennal region 0.19 x 0.33 mm. (index 1 : 1.74). Hind-head 0.19 x 0.40 mm. (index 1 : 2.11). Marginal carina is interrupted medially and there is a well-marked dorsal suture. Anterior plate well demarcated. Prothorax 0.09 x 0.25 mm. Pterothorax 0.19 x 0.36 mm. Abdomen 0.85 x 0.59 mm. Tergal plates II and III with a single tergo-central seta ; IV with one tergo-central and one tergo-lateral seta ; V with one tergo-central and 2 tergo-lateral setae ; VI with 2-3 tergo-lateral and one tergo-central seta ; VII with 2-3 tergo-lateral setae ; VIII with three setae on each side ; IX with 2 long tergo-lateral and 5 small tergo-central setae and X+XI with three anterior and two posterior setae on each side.

Genital armature 0.0252 mm. long. Basal plate 0.0184 mm. long, anterior width 0.0098 mm. and posterior width 0.0069 mm., strongly convex in the anterior region and runs almost parallel from the middle to the apical margin. Parameres sabre-shaped with nearly straight inner margin, proximal heads of the shape shown in the figure, comparatively well developed in one facies than the other, 0.0069 mm. long. Mesosomal plate showing distinct central apophysis with reinforced sides, 0.0063 mm. long.

FEMALE : 1.82 x 0.64 mm. Head 0.42 x 0.47 mm., cephalic index 1 : 1.12. Preantennal region 0.19 x 0.39 mm. (index 1 : 2.05). Hind-head 0.23 x 0.47 mm. (index 1 : 2.04). Prothorax 0.10 x 0.27 mm. Pterothorax 0.19 x 0.41 mm. Abdomen 1.11 x 0.64 mm. Tergal plates II-IX with one tergo-central seta ; IV-VII with one tergo-lateral seta, VIII+IX with two tergo-lateral setae on each side. Sternal plates as in other species. Subgenital plate blunt posteriorly. Vulvar plate with 5-6 marginal setae on each side, beset as shown in the figure.

MATERIAL EXAMINED : One female from Iman (Wd. Eichler, Collection No. 36886), one male and one female from Whetestow, England (B. M., April 1953, 356). All from the Blackbird *(Turdus m. merula* Linn.). Three males and one female from Palestine (Meinertzhagen, April 1953, slide No. 20143), taken of *Turdus merula syriacus*, also resemble the above specimens in all details.

REMARKS : As far as the general body and shape of the head are considered, this species falls in *Bruelia marginata* group. The abdominal chaetotaxy of *Bruelia longifrons, B. longifrons antiqua, B. myiophoneae, B. marginata, B. viscivori, B. turdinulae* and *B. oudhensis* is more or less similar. The head in *B. longifrons, B. l. antiqua,* and *B. myiophoneae* is truncate while in others it is thimble-shaped. Basal plate in *B. tnrdinulae* and *B. oudhensis* is 3.5-4.5 times as long as mesosome and in *B. marginata, B.*

viscivori B. amsel, and *B. ilmasae* the ratio between the mesosome and basal plate is 1 : 2.05-2.41 only. In *B. marginata* and *B. amsel* V-VII abdominal segments are with 2+1+1+2 dorsal setae, while in *B. ilmasae* there are 1+ 1+1+1 dorsal setae.

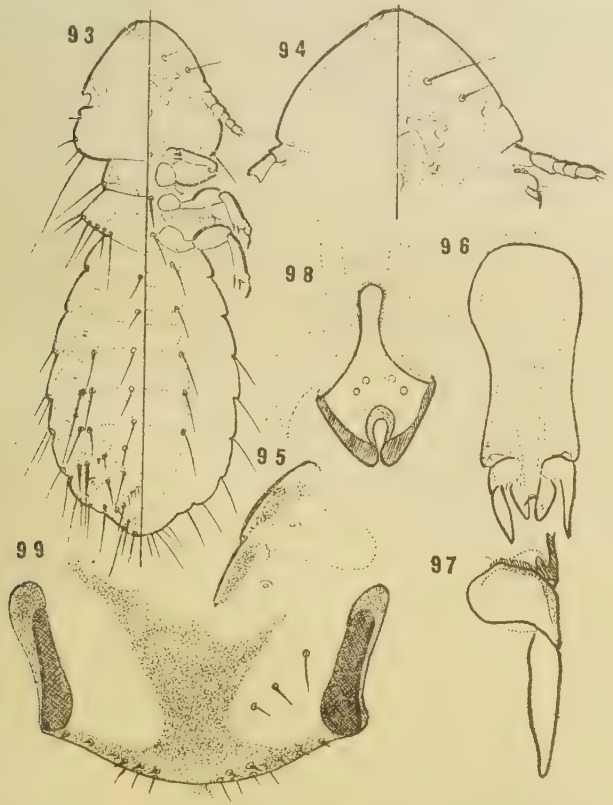
16. **Bruelia viscivori** (Denny)

(Text-figs. 93-99)

Nirmus viscivori Denny, 1842, *Mon. Anopl. Brit.*, p. 50 and 124, pl. 7 fig. 7.

TYPE-HOST : *Turdus viscivorus viscivorus* Linn.

MALE : 1.39 x 0.51 mm. Head 0.37 x 0.40 mm., cephalic index 1 :



Text-figs. 93-99. *Bruelia viscivori* (Denny) : (93) dorsal and ventral aspects of male, (94) a portion of the head showing marginal carinae, (95) a portion of the abdomen showing tergal plate, (96) male genital armature, (97) paramere, (98) mesosome, (99) a portion of subgenital plate of female showing marginal chaetotaxy.

1.08. Preantennal region 0.17 x 0.32 mm. (index 1 : 1.90). Marginal carina as in *B. amsel*. Anterior plate well pigmented, concave anteriorly and convex posteriorly. Ventral carina is distinctly divisible in anterior and posterior components, posterior portion is heavily pigmented and thicker than the anterior component. Temples convex. Gular plate well developed, anterior portion squat, equilateral triangle with acutely angulate apex, posterior portion trapezoidal in shape. Hind-head 0.20 x 0.40 mm. (index 1 : 2.00).

Prothorax 0.08 x 0.23 mm., sides straight and slightly divergent, latero-posterior angle with a long seta. Pterothorax 0.15 x 0.36 mm. strongly diverging, median posterior angle obtuse, latero-posterior angle with one very small and one long seta followed by 5-6 long and subequal setae on each side. Thoracic sternites well formed, spherical with a single small antero-lateral seta on each side.

Abdomen 0.79 x 0.51 mm., ovate, narrow anteriorly and broader posteriorly, widest at V-VI segments. Tergal plates II-VIII separated widely in the middle line ; IX approximate. Tergites II-VIII with one tergo-central seta; IV and VIII with one tergo-lateral seta also ; V-VII and IX with two subequal tergo-lateral setae ; IX with 7 short setae on each side. Terminal segment rounded, with two rows of three setae on either side. Pleural plates with elongate re-entrant heads, inwardly directed to the segment in front. Abdominal sternites II-VI with a single seta on each side.

Genitalia 0.0253 mm. long. Basal plate 0.0183 mm. long, more or less three times as long as parameres, wider anteriorly (0.0089 mm.) and narrow distally (0.0077 mm.), concave in the middle. Parameres moderately long, 0.0072 mm., regularly tapering. Proximal heads considerably projecting inwards. Mesosome 0.0071 mm. long, of the pattern shown in the figure, with distinct central apophysis reinforced by spindle-shaped lateral sclerotizations.

FEMALE : Similar to male, 1.76 x 0.57 mm. Head 0.42 x 0.44 mm., cephalic index 1 : 1.05. Preantennal region 0.21 x 0.37 mm. (index 1 : 1.76). Hind-head 0.21 x 0.44 mm. (index 1 : 2.00). Prothorax 0.09 x 0.27 mm. Pterothorax 0.17 x 0.39 mm. Abdomen 1.08 x 0.57 mm. Tergites II-VIII with one moderately long tergo-central seta on each side ; IV-VIII with such tergo-lateral seta ; IX with 3 very short setae. Sternal plates as in male. Subgenital plate well developed, anterior portion 'top-shaped' with blunt distal end placed on the arched cross bar. Vulvar plate with 9-10 setae on each side disposed of as shown in the figure. Pleural plates II and

III bare ; IV with three, V and VI with three, VII with four and VIII with seven setae.

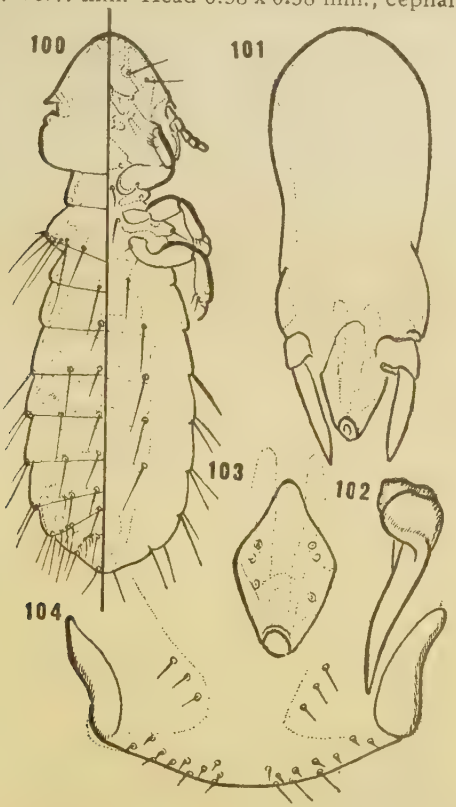
MATERIAL EXAMINED : One male from Arren Stiddery, Scotland (Waterston, August 18, 1927, B.M. 1930-432), 2 males, 7 females from Tring (April 19, 1936-250), one male and 16 females from Suffolk (Meinertzhagen, June 1937, 8359), one male from Co Cork, Ireland (Meinertzhagen, January 1953, 20128). All from *Turdus v. viscivorus* Linn.

17. **Bruelia ilmasae** sp. nov.

(Text-figs. 100-104)

TYPE-HOST : *Turdus olivaceus olivaceus.*

MALE : 1.54 x 0.47 mm. Head 0.38 x 0.38 mm., cephalic index 1 : 1.00.



Text-figs. 100-104. *Bruelia ilmasae* sp. nov. (100) dorsal and ventral aspects of male, (101) male genital armature, (102) paramere, (103) mesosome, (104) a portion of the subgenital plate of female showing marginal chaetotaxy.

Preantennal region 0.81 x 0.31 mm. (index 1 : 1.72). Marginal carina interrupted anteriorly in the middle and incompletely interrupted laterally. Dorsal suture well marked laterally, anterior plate well marked. Hind-head 0.20 x 0.38 mm. (index 1 : 1.90).

Prothorax 0.09 x 0.25 mm. with a single lateral seta. Pterothorax 0.15 x 0.37 mm., with six moderately long setae as shown in the figure.

Abdomen 0.92 x 0.47 mm. Tergal plates II-VIII completely divided in the middle ; IX approximate ; II-VIII and X with one tergo-central seta ; IV-VII with one tergo-lateral seta ; VIII with three tergo-lateral setae and IX with 3 long and three short setae. Last segment with one dorsal, one ventral and one marginal seta on each side. Sternal plates as in other species ; II-VI with one long seta on each side.

Genitalia 0.0212 mm. long. Basal plate 0.0141 mm. long, anterior and distal width almost equal (0.0080 and 0.0075 mm. respectively), fairly concave in the middle. Parameres 0.0063 mm. long, narrow and pointed, outwardly bent from about the middle, proximal head well built as shown in the figure. Mesosome shield-shaped, anterior angulation pulled backwards as in *B. marginata*. Central apophysis well developed and reinforced laterally ; 0.0069 mm. long.

FEMALE : Similar to male, 1.80 x 0.53 mm. Head 0.41 x 0.44 mm., cephalic index 1 : 1.07. Preantennal region 0.21 x 0.35 mm. (index 1 : 1.71). Hind-head 0.20 x 0.44 mm. (index 1 : 2.20). Prothorax 0.10 x 0.26 mm. Pterothorax 0.18 x 0.39 mm. Abdomen 1.11 x 0.53 mm. ; II-VIII tergites with one tergo-central and one tergo-lateral seta on each side. Last segment with three short setae on each side. Sternal plates as in other species. Subgenital plate blunt posteriorly. Vulvar plate squat, with feeble posterior arch, marginally beset with 9-10 small setae.

MATERIAL EXAMINED : HOLOTYPE (male), ALLOTYPE (female) and PARATYPES (one male and two females) from Potchefssstroom, W. Transvaal. All collected from *Turdus olivaceus olivaceus* on 1.X.1933. HOLOTYPE (male) in South African Institute for Medical Research, Johannesburg.

REMARKS : This species belongs to the group of *B. marginata*. It closely resembles *Bruelia inornata* Timmermann from which it can be differentiated by the fore-head, male genital armature and subgenital plate of female.

REMARKS ON SOME UNIDENTIFIABLE SPECIES

18. **Bruelia antimarginalis** Eichler

Bruelia antimarginalis Eichler, 1951, *Bedeutung der Vogelwelt* in *Forschung und Praxis*, 40, figs. 12.

This species was erected by Eichler (1951) to accommodate a single

female specimen he collected from *Turdus pilaris*. As the figure of the head and its measurements (0.40 x 0.31 mm.) show, it was a narrow-headed form. However, the specimens from *Turdus pilaris* now before me are broad-headed forms (female 0.39 x 0.41 mm. ; male 0.35 x 0.36 mm.). Since the females of several species of *Bruelia* are identical, it is not justifiable to create a new species merely on the basis of a female. The validity of Eichler's *B. antimarginalis* is therefore doubtful, particularly because a narrow-headed male, corresponding to the female described by him has not been found on *Turdus pilaris*. Miss Clay (personal communication) has suggested that the narrow-headed female, to which Eichler gave the specific name *Bruelia antimarginalis*, could be a straggler and not a regular parasite of that bird. It is unidentifiable at present.

19. **Bruelia jacobi** Eichler

Bruelia jacobi Eichler, 1951, *Bedeutung der Vogelwelt* in *Forschung und Praxis*, 38.

This species was described from males and females obtained from *Turdus merula merula* Linn. It is a narrow-headed species (0.38 x 0.23 mm.). I have two species from this host in the Collection under discussion. In one species (*B. merulensis*) the head measures 0.55 x 0.59 mm. in the male and 0.56 x 0.63 mm. in the female, while in the other (*B. amsel*) it measures 0.38 x 0.40 mm. in the male and 0.42 x 0.47 mm. in the female. Whether Eichler's specimens belong to a different species cannot be said with certainty, particularly because he has neither given a good description nor a figure of the male genitalia. Moreover, despite all efforts, the type material could not be secured for these studies.

20. **Bruelia intermedia** (Nitzsch)

Nirmus intermedia Nitzsch, 1866, *Z. ges. Nat Wiss.* 28, p. 366.

This species was recorded from *Turdus pilaris* Linn. and *Turdus torquatus alpestris* Brehm. I have examined specimens from *T. pilaris* and have found that they could be assigned to the species *Bruelia marginata* (Burmeister). I did not have the oppostunity of studying any specimen from the second host, but if the parasites from the two hosts belonged to the same species, *Bruelia intermedia* should be regarded as a synonym of *B. marginata*. This is what Miss Clay has suggested to me. However, I have observed that quite commonly a host harbours two distinct species of *Bruelia*. It is therefore possible that *Turdus pilaris* bears another species in addition to *B. marginata* whose occurrence I have verified. The possibility of a distinct species from the other host is also to be kept in view. Efforts should therefore be made to obtain some collection from the other

host. Till further studies of this type have been made, the identity of the species *B. intermedia* will remain doubtful.

21. **Bruelia vulgata** (Kellogg)

Nirmus vulgata Kellogg, 1896, *Occ. Pap. Calif. Acad. Sc.*, 2 (6) : 495, pl. 67 fig. 6.

Kellogg (1896) recorded this species from a variety of dissimilar birds inculuding True Thrushes *Turdus migratorius migratorius* Linnaeus. Unfortunely the type host has not so far been fixed. Miss Clay (Personal communication) presumes one of the Finches mentioned near the beginning of the host list given by Hopkins & Clay (1952, p. 63) to be the true host of this species. It is therefore difficult to do much with this species until a type-host has been finally decided.

HOST-PARASITE INDEX

	BIRD HOST.	PARASITE.
1.	*Hylocichla guttata*	*Bruelia longifrons antiqua* subsp nov.
2.	*Hylocichla ustulata*	*Bruelia longifrons* sp. nov.
3.	*Myiophoneus coeruleus temminckii*	*Bruelia myiophoneae* (Clay)
4.	*Turdus dauma aureus*	*Bruelia daumae* (Clay)
5.	*Turdus dauma dauma*	*Bruelia daumae* (Clay)
6.	*Turdus merula merula*	*Bruelia amsel* (Eichler)
7.	*Turdus merula syriacus*	*Bruelia merulensis* (Denny) *Bruelia amsel* (Eichler) *Bruelia merulensis* (Denny)
8.	*Turdus merula nigropileos*	*Bruelia oudhensis* sp. nov.
9.	*Turdus migratorius propinquus*	*Bruelia iliaci brevicolor* subsp. nov.
10.	*Turaus musicus musicus*	*Bruelia iliaci* (Denny)
11.	*Turdus philomelos philomelos*	*Bruelia turdinulae* sp. nov.
12.	*Turdus philomelos clarki*	*Bruelia turdinulae eternitatus* subsp. nov.
13.	*Turdus olivaceus olivaceus*	*Bruelia ilmasae* sp. nov.
14.	*Turdus pilaris pilaris*	*Bruelia marginata* (Burmeister)
15.	*Turdus ruficollis atrogularis*	*Bruelia iliaci indiensis* subsp. nov.
16.	*Turdus viscivorus viscivorus*	*Bruelia viscivori* (Denny)
17.	*Zoothera marginata parva*	*Bruelia zootherae* (Clay)
18.	*Zoothera monticola monticola*	*Bruelia stresemanni* (Clay)

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